ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Vol. XLVIII. No. 10.

TABLE OF CONTENTS.

(24 pages; no inset.)

ENGINEERING NEWS OF THE WEEK..... 157
Steel Dome for West Baden, Ind., Hotel; The Largest Dome in the World (illustrated)..... 158
The Black Diamonds of Bahia, Brazil..... 159
50-Ton Steel Coal Car with Westinghouse Friction Draft Gear; Pennsylvania R. R. (illustrated).... 159
The Base-Line Measurements for the 98th Meridian Triangulation (illustrated) 162
Tests of Various Paints on the 155th St. Viaduct; New York City 164
A Pumping Plant for Raising Condensing Water to an Electric Power Station (illustrated)..... 165
The Kazusa System of Artesian Well-Boring in Japan 165
A Graphical Method of Computing Swing Bridges (illustrated) 166
Simple and Rapid Tests for Cement 166
Couplings for Sewer Cleaning Rods (illustrated).... 167
Commercial Success in Long-Distance Electric Power Transmission 167
Augustus Torrey (With Portrait)..... 171
The Adjustment of Macadam Road Design to Various Sub-Grade Soils 171
A New Rotary Beveling Machine (illustrated)..... 172
Water-Power Projects at Joliet, Ill. (illustrated)... 172
Annual Meeting of the League of American Municipalities 173
Statistics of Railways in the United States for the Year Ending July 30, 1901..... 174
Uralite: A New Fireproofing Material..... 174
Reheating Air for a Compressed Air Mine Hoist Driven by Electric Power (illustrated)..... 175
Crenothrix as a Source of Trouble in Public Water Supplies 175
Report of the British Admiralty Committee on Naval Boilers (illustrated) 176
A Novel Application of Conveying Machinery (illustrated).. 180
EDITORIAL NOTES..... 168
A Combination Boiler Equipment for Cruisers and Battleships—Heavy Freight Train Loading on the Chicago & Eastern Illinois R. R.—Comparative Weights of English and American Passenger Trains—The Electric Motor for Mine Hoists—Dispensing with Ultra-Refinement in Base-Line Measurements—The Supply of Brazilian Diamonds for Diamond Drills—The Obsolete Hennepin Canal—Effect of California Fuel Oil on Long-Distance Electric Transmission Enterprises.
EDITORIAL:
Concerning Fireproof Wood—So-Called..... 169
LETTERS TO THE EDITOR..... 170
A Concrete-Steel Retaining Wall—Cost of Laying Brick Pavements—Reheating Steam Between the Cylinders of Compound Engines—The Law of Boundary Surveys; Chains and Links the Standard for Government Land Measure—Practice in Subdividing Lands Below an Original Meander Line—Notes and Queries.

FULL MUNICIPAL OWNERSHIP of the water-works of Austin, Tex., has at last been secured through the purchase of the company's plant by the city. The private works were built in 1875 by the City Water Co., and were subsequently transferred to the Austin Water, Light & Power Co. In 1891-5 the city built competing works, including the famous dam across the Colorado River, which was destroyed in April, 1900. The city pays the company $175,000 for its works and $85,000 in judgments, the latter on account of services rendered by the company and contested by the city. There has been much litigation between the city and the company, and the latter has for some time been in the hands of a receiver.

BIDS FOR A SEWER IN TUNNEL are soon to be invited by the Bureau of Sewers of the Borough of Brooklyn, New York City. The sewer will be 132 ins. in diameter and over a mile in length, extending beneath 92d St. from 11th Ave. to New York Bay. It is estimated to cost $665,000. The lower end of the sewer will extend into salt water for about 425 ft., and it will be built of concrete and expanded metal, brick-lined, all resting on piles. The following clause in the specifications makes it particularly desirable that prospective bidders begin to post themselves as soon as possible on the material likely to be encountered on this work:

Each bidder is expected to carefully examine the location of the work before making his proposal, and must satisfy himself as to the nature and geological formation of the several strata through which the tunnel and open cut work will be built. In order to determine the above data to his satisfaction, and also the elevation of the ground-water or spring level, he will be permitted, prior to making his proposal, to sink test wells or to make borings at his own expense. It is distinctly understood and agreed that the price bid per linear foot for the tunnel sewers shall include the cost of building the same complete, whatever the geological nature of the several strata through which it is driven may be; it is also distinctly understood that the city does not guarantee in any manner the formation of said strata.

Mr. Henry R. Asserson, M. Am. Soc. C. E., is Chief Engineer of the Brooklyn Bureau of Sewers.

THE NEW ORLEANS SEWERAGE BIDS on work including nearly 100 miles of sewers have been declared too high by Superintendent Earl and the Executive Committee of the Sewerage and Water Board, and re-advertisements for nearly all the work have been recommended.

CIVIL SERVICE EXAMINATIONS for ships' draftsmen will be held at the New York Navy Yard on Sept. 9, 1902. The following vacancies are to be filled: Department of Construction and Repair—One first-class leading ship draftsman, $6 per diem; two third-class ship draftsmen, $4 per diem; one first-class assistant ship draftsman, $3.28 per diem. In addition to filling the above vacancies, the department desires to establish an eligible register in the following grades: Ship Draftsmen—First-class, $5.04 per diem; second-class, $4.48 per diem; third-class, $4 per diem; fourth-class, $3.60 per diem; Ship Assistant Draftsmen—First-class, $3.28 per diem; second-class, $2.80 per diem; third-class, $2.40 per diem; fourth-class, $2 per diem. The examination will be open to all comers who can give evidence of experience in the kind of work for which they seek employment, and who are citizens of the United States. Persons now holding positions at the yard will be admitted to competition on the same footing as other applicants. Applications will be addressed to the Commandant, Navy Yard, New York, and must be delivered to him on or before Monday, Sept. 8, 1902. No application received after that date will be considered.

INJUNCTION RESTRAINING WORK on Section IV. of the New York Rapid Transit Railway has been denied by Justice Giegerich, of the Supreme Court. Section IV. of the rapid transit railway comprises that portion passing by tunnel under Murray Hill, on which a rock slide destroyed the fronts of several residences some months ago. Application for injunction to stop further work was made by Mr. C. T. Barney, one of the injured property owners. The opinion handed down by the Justice is one of particular interest, and is in abstract as follows:

The gravamen of the action is the alleged unlawful act of the defendants in so directing the construction of the rapid transit tunnel under Park Ave. between 34th and 42d Sts. that the easterly wall of the tunnel is made to follow a line distant only 7 ft. from the building or house line of the street, it being claimed that in the plan of construction adopted there is a substantial departure from the maps and descriptions prepared by the Board of Rapid Transit Commissioners, in accordance with the statute which created their powers, the legality of their acts in causing the building of the tunnel being dependent upon their following the scheme of construction outlined or described in these maps and descriptions styled for the purposes of the case "routes and general plan." It appears that the tunnel at this point was delineated by the drawings, which formed a part of the routes and general plan as under the center of the street with its easterly wall distant some 37 ft. from the building or house line. If these drawings, with their attendant description, were to control the method of construction, then the present method is unlawful, because of the very substantial divergence in plan which has resulted. These necessary details the "routes and general plan" undertook to show for the advisement of all persons interested, and in order that intelligent action might be taken by them to conserve their best interests in the subsequent proceedings for the confirmation and approval of the plan. Taking the words used in the "routes and general plan" with the plans or drawings to which they referred, no person could be expected to apprehend that the fixed position of the tunnel, as under the central portion of the street, was subject to such a change as would bring it for about ten blocks to a point 30 ft. nearer the building or house line than was indicated, merely because "suitable connections" were to be made near 42d St. A civil engineer might have found that something was omitted or that there was a variance between the plan, which showed the means of making connections, and the specifications which mentioned the proposed connections, but a layman, for whose advisement the "routes and general plan" had been prepared under the statute, could properly assume that, in some way best known to engineering science, these "suitable connections" were to be made from a tunnel under the middle of the street. Certainly he could rely upon the general proposition that the scientific construction of a railway, with the necessary curves for the approach toward a given point, does not depend upon guesswork or chance, and I think, therefore, that no reasonable interpretation of the "routes and general plan" would afford room for justifying the extraordinary change in the position of the tunnel, as constructed, from the line described in the lawfully approved plan of construction as to this particular locality. The fact being that the work of building the tunnel at the point in question is prosecuted without legal authority, there is technical support for the plaintiff's action, which is directed against the expenditure of public funds for an unlawful purpose, but upon the facts disclosed it is perfectly clear that the remedy sought by way of an injunction is no remedy, and that to grant so-called "relief" in this form would be preposterous. The work of construction has advanced so far that the cost of completing it will about equal the necessary expense which must be incurred in properly refilling it if abandoned. To enjoin the further construction must involve the requirement, by mandatory injunction, that the part excavated be restored, for the safety of

ANOTHER DISASTROUS ERUPTION OF MT. PELEE occurred on Aug. 30, in which the villages of Morne Rouge and Ajoupa Bouillon, lying in valleys adjacent to the volcano, were destroyed and over a thousand lives were lost. The nature of the destruction is not reported in the cable dispatches. The volcano La Soufrière, on the island of St. Vincent, B. W. I., was also alarmingly active, so that an outbreak was feared, at the same time that this last eruption of Mt. Pelee took place. It will be remembered that La Soufrière destroyed a large part of St. Vincent at the time when Mt. Pelee overwhelmed the village of St. Pierre with its 30,000 inhabitants in May last.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Southern Ry. near Berry, Ala., on Sept. 1. An excursion train was derailed while rounding a curve at the top of a high embankment, and the engine with half of the train of ten cars rolled down into the ditch. About 25 persons were killed outright and nearly 100 injured, of whom over a score may die.——Several other fatal train accidents occurred. Of these, one which occurred on the Chicago & Northwestern Ry. near Owatonna, Minn., on Aug. 30, deserves to be noted. A westbound passenger train, going at a moderate rate of speed, was struck by a tornado, which blew three passenger cars from the track and down the embankment. Two or three persons were killed in the wreck.

OIL AS FUEL FOR STEAMSHIPS seems to be meeting with much success on the Pacific Coast. A recent instance of this, as noted in the San Francisco "Examiner" of Aug. 21, is the case of the freight steamer "Nevadan," running between San Francisco and Honolulu. This steamer was fitted with oil-burning furnaces a short while ago, and the experience with them in actual trans-Pacific steaming has been most satisfactory. The principal advantages of the oil fuel appear to be its cleanliness and the large saving in the space required for fuel storage.

ALCOHOL AS A SOURCE OF MOTIVE POWER has been experimented upon by Professor Behrend, of the Technical Institute of Hohenheim. His experiments were made in a Koerting engine of 6 HP. nominal, with three mixtures of alcohol, as follows: (1) Alcohol denaturalized for commercial purposes. (2) Alcohol with benzine added to the extent of half the volume of the ordinary denaturalizing agent. (3) The same mixture as No. 2 with 18% benzine added. The results were as follows:

Mixture.	Quanity consumed per B.HP.-hour, kilogram.	Cost of spirit per B.HP.-hour, franc.
1	0.595	0.149
2	0.585	0.146
3	0.519	0.130

The alcohol cost 25 francs per hectolitre; and by adding benzine this is reduced 0.837 franc per hectolitre. The cost of running with petroleum is about 0.125 franc per B. HP.-hour.

THE PRUSZHOWSKI WATER MOTOR FOR ROCK drilling, for deep holes, is a device for utilizing the flushing water—instead of the boring rod, for conveying motive power to the boring tool. The rods either stand still, or are raised and lowered or turned; but the actual boring is done by a hydraulic motor attached to the bottom of the rods. The water under pressure is fed through the hollow rod to the motor, and the escape water does the flushing. It, in fact, substitutes a more powerful pump for the ordinary drilling engine. This device, and two other hydraulic motors for boring, invented by Messrs. Howarth and Wolski, are described and illustrated in a paper presented at the late meeting of the International Society of Boring Engineers, held at Frankfort, Germany. The paper concludes by saying that the idea is too new to enable any opinion to be given as to practical results; the only tests yet made have been in drilling blocks of stone. With a drive pipe and piston 2 ins. diameter, and a working pressure of 170 lbs., the motor gave 12 strokes per sec. and consumed 1.1 gallons of water, and the 8-in. bit drilled through very hard sandstone at the rate of 26 ins. per hour; in soft sandstone it drilled at the rate of 23 ft. per hour.

A TURN-TABLE for connecting incline railways with lateral branches has been developed in Germany, and is in use at the German Solvay Process Works at Bernburg and at the basalt works of Chr. Ohrmacher at Obercassel, Germany. The turn-table is adjustable to any incline from 0° to 28°, and can be used either on cable inclines or gravity railways. Its principal use, of course, is to connect the rail lines of a mine entered on a slope with the tracks that branch off at the different levels. The apparatus is manufactured in Germany by the Sieg-Rheinische Huetten-Actien-Gesellschaft, of Friedrich-Wilhelms-Huette.

A MUNICIPAL EXHIBITION is to be held next summer in Dresden, Germany. Our informant, the "Centralblatt der Bauverwaltung," states that over a hundred German cities will take part, and that the capital cities of almost all European states, as well as the cities of New York, Washington, and Philadelphia, will be invited. The exhibition is to be opened on May 20, 1903, by the imperial chancellor, v. Bülow; all articles intended for exhibition must be received before April 15, 1903, in case of the municipal section, or before May 10, 1903, in case of the industrial section.

ABOUT 2,500 ARTESIAN WELLS have been drilled by the Cape Colony government during the past dozen years, in aid of agricultural development. About three-fourths of these were successful in striking water, usually at depths of 50 to 500 ft. These wells supply from 1,000 to 50,000 gallons per day, the supply being raised by deep well pumps. Most of the holes have been put down with diamond drills. Soon after the outbreak of the war these government well-boring outfits were taken into the field to provide water supplies for the British forces and accomplished remarkable results.

STEEL DOME FOR WEST BADEN, IND., HOTEL; THE LARGEST DOME IN THE WORLD.

The large new hotel now in course of construction at West Baden, Ind., is to be surmounted by a domed roof remarkable for its great size. This dome has steel framework and is larger than any other ever built, its span exceeding by about 15 ft. that of the great dome of the Horticultural Building at the Chicago Exposition of 1893. The accompanying views and drawings give an excellent idea of the appearance of this great structure, and make clear its construction and erection.

The general form of the dome is well shown in Fig. 1, which is a view taken when the steel framework was practically completed. The dome is about 200 ft. in outside diameter, and rises about 50 ft. above its bed-plates. Its frame consists of 24 steel ribs, all connected at the center or crown to a circular plate drum, and tied together at the bottom by a circular plate-girder tie. Each rib foots at its outside end on a built-up steel shoe, resting on a masonry pier. The rib is connected to the shoe by a steel pin, and the outside plate-girder tie is attached to the gusset plate at this point, just above the shoe. The shoes of all the girders are constructed as expansion bearings, being provided with rollers in the usual manner.

It will be seen from this description that the dome-framing is virtually an aggregation of two-hinged arches with the drum at the center forming their common connection. Their thrust at the foot goes into the circular tie-girder, and only vertical loads (and windloads) come upon the shoes and the bearing piers. At the same time any temperature stresses are avoided, since the expansion rollers under the shoes permit a uniform outward motion of the lower ends of all the ribs.

Fig. 2 shows one of the arch-ribs in outline, and gives also a part plan of the dome-framing. As will be seen, the rise of the arch, 43 ft. from center of pin to middle of rib, is something between one-fourth and one-fifth of the span, which is 195 ft. between centers of pins. The outline of the top chord approximates an elliptical curve,

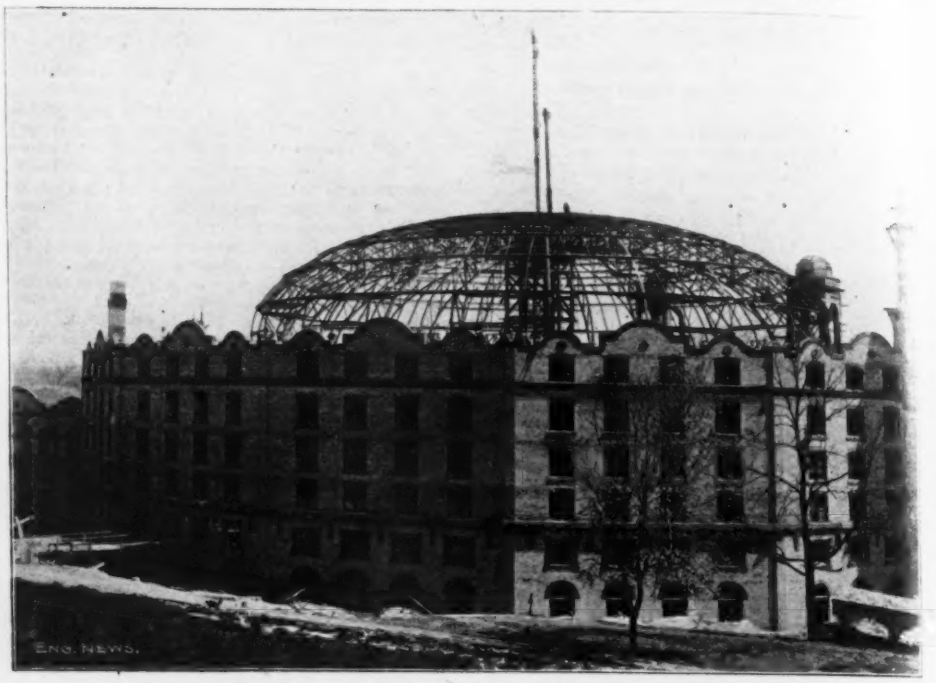


FIG. 1. GENERAL VIEW OF WEST BADEN HOTEL IN COURSE OF ERECTION, SHOWING STEEL FRAMEWORK OF DOME NEARLY COMPLETED.

H. Albright, Charleston, W. Va., Architect; Illinois Steel Co., Contractors for Steelwork; Oliver J. Westcott, Designer of Steelwork.

Pratt type, with substruts to the top chord as purlin supports. In the end sections the arrangement is necessarily modified, and the sharper curvature of the chords is allowed for by more frequent strutting.

The maximum stresses in the different members of the arch are noted on the right half of the rib, in Fig. 2. They were obtained by properly combining the dead load stresses with the stresses due to wind assumed blowing successive-

sq. ft. of normal surface, reduced for the inclination of the roof to the vertical. The make-up of the members is given in Fig. 2, on the left half of the rib. It will be seen that their design follows closely the usual American practice in roof work; the stresses in no case are higher than can be comfortably provided for by the ordinary double-angle section.

In the plan of part of the dome, Fig. 2, the method of bracing the ribs is clearly shown. Suc-

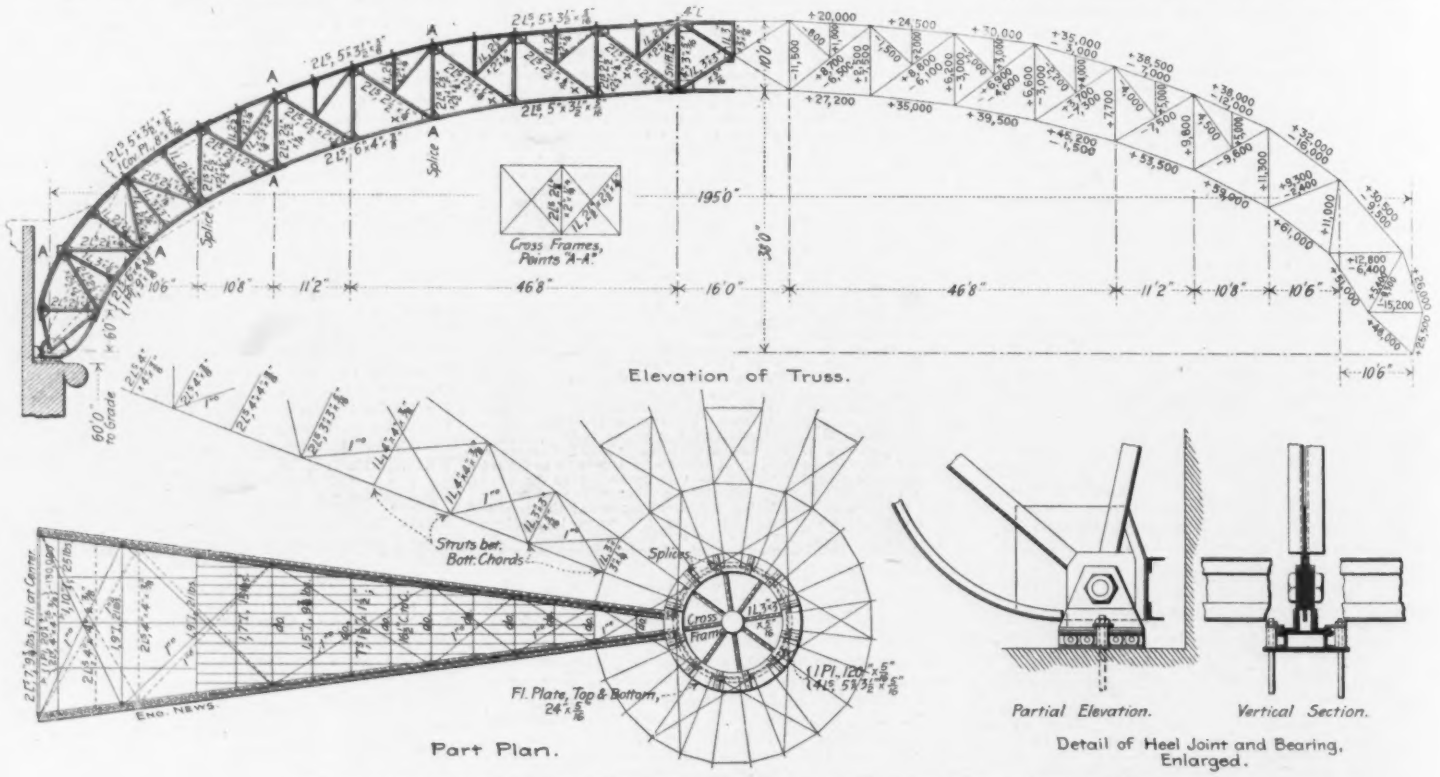


FIG. 2. PART PLAN AND SECTION STEEL FRAMING OF DOME OF WEST BADEN HOTEL.

and the bottom chord is parallel to the top chord throughout its length, except in the three end panels on either side, the depth of the arch being 10 ft. back to back of chord angles. The web members are arranged as a single system of the

ly in opposite directions in the plane of the rib in question. The loads used in the calculation were a dead load separately estimated for each panel point, a variable snow load, heaviest at the center of the roof, and a wind load of 30 lbs. per

cessive pairs of ribs are connected by bays of bracing in both upper and lower chords. In the upper chord the I-beam purlins are made use of as struts, angle struts being used in the lower chord. The bracing consists throughout of crossed

adjustable rods. At the center, these rods are carried over to a tangential attachment to the central drum, so as to give more rigidity against twisting of the center.

The central drum, 16 ft. in diameter by 10 ft.

Fig. 3. Dome Under Erection, Showing Method of Supporting Central Drum.

deep, has a web of ⅜-in. plate, with stiffener angles to which the ribs are attached. At top and bottom the drum carries a flange plate 24 ins. × 5-16-in., for lateral stiffness. In addition it is cross-braced internally by four diametrical frames intersecting at the center. The outer tie-girder, which takes the thrust of the arch-ribs, is a simple channel-shaped plate girder, 24 ins. deep, as shown in the plan. The weight of the dome complete, including framework and covering, was 475,000 lbs. This makes the dead load about 15 lbs. per sq. ft. of horizontal projection of roof surface.

The erection of this dome is a matter of some interest. Figs. 3 and 4 are views of the partly-erected structure. The method used was as follows: A falsework tower was built up from the ground to the level of the bottom of the drum in the center of the dome, and a boom derrick mounted upon it. The derrick was strongly guyed at the bottom as well as the top of the mast, so as to avoid lateral stresses on the tower. The large central drum was then erected in its true position on top of the tower and fully riveted up. The ribs were assembled separately on the ground, and by means of the derrick were raised one at a time into position, and connected to the drum. The work proceeded thus alternately on opposite sides of the dome, so as to get the ribs into their arch relation and prevent the tower being forced out of center. The first rib raised displaced the top of the tower several inches, on account of the stretching of the long wire cable guys, but when the second rib, immediately opposite, was placed, it brought the tower back to its original position. The falsework tower was removed only after all of the arches, tie-girder, purlins, and bracing had been placed and riveted up.

The general design for the West Baden Hotel was conceived by the owner, Mr. L. W. Sinclair. The architect for the structure was Mr. Harrison Albright, of Charleston, W. Va. The Illinois Steel Co. furnished the design for the steel dome and built the same; the design was originated and worked out by Mr. Oliver J. Westcott, then in charge of the estimating department of the Illinois Steel Co., and now of the engineering and contracting firm Stephens & Westcott Co., 774 Rookery, Chicago. The general contractors for the building are Caldwell & Drake, of Columbus, Ind.

THE BLACK DIAMONDS OF BAHIA, BRAZIL.

U. S. Consul H. W. Furniss, of Bahia, Brazil, reports upon diamonds and carbons, the latter being the stones used in diamond drills. The geological formation of this region is very interesting. The rock is eruptive, and the carbon, by great heat and pressure, has crystallized into diamonds; with conditions perfect the diamond of commerce was produced; with less perfect conditions the carbon failed to crystallize and appears in hard, blackish masses of irregular shape, known in trade as carbon or black diamonds.

The original rock is granitic, and mixed with this is a sandstone of different degrees of hardness, and a conglomerate of rounded pebbles cemented by a very hard matrix, often resembling a dark-colored cement. Both sandstone and conglomerate are of more recent formation than the granite, and they contain the diamonds. These precious stones are thus not found in situ, but occupy their position as a result of fluvial action.

The diamonds and carbons cannot be removed from either the sandstone or conglomerate because of the impracticability of breaking the rock without crushing the precious stones. The miners, therefore, work in the gullies between the rocks and in the cavities about them, depending upon the disintegrating influence of time and the elements, and the washing down of this debris into the ravines and river beds.

The method of mining here employed is of a crude type. The "cascalho" or diamond-producing debris is mined in the open or by tunnels, and at the end of each week this accumulation is laboriously washed, either in a sluice with running water, or in large wooden basins manipulated by hand. In another method of mining a diving-bell is used, and in the Paraguaca River, near Tamandoa, as many as a hundred native divers work the river bed, collecting the gravel into sacks, which are hoisted into canoes and taken ashore. Mr. Furniss says that with improved machinery and modern methods much better results could be secured. Some of the most productive locations cannot be worked because the water leaks in faster than it can be bailed out by hand; here, even, a good hand pump would much improve conditions.

The output of carbons now averages about 2,500 carats per month, but the output is decreasing while the demand is constantly increasing. Mr. Furniss says that immense quantities of carbons undoubtedly exist in that region, but it will take well-managed companies with large capital to mine them profitably.

Carbons are classified as porous, or crystalline and good. The good stones are now worth at the mines $24 per carat, if the stone is over ¾-carat in weight; for stones of ½ to ¾-carat, the price is $7.20 per carat; carbons of less than ½-carat are mixed with "refugo" diamonds, worth $48 per oitava. The porous carbons bring half these figures, but not more than 5% of the stones mined belong to this class. The largest carbon ever discovered came from the Lencoes district; it was found in 1895, and weighed 3,150 carats. It was sold by the miner for $16,000, one-fourth of this going to the owner of the claim; this stone was finally sold for $25,400 and sent to Paris to be broken up into marketable pieces. The next big find was in 1901, when near the same place as before a carbon of 577 carats was unearthed; this was sold by the miner for $17,380. The average size of the carbons found is 6 carats. All diamonds and carbons from this district are shipped to Paris and London from Bahia City.

50-TON STEEL COAL CAR, WITH WESTINGHOUSE FRICTION DRAFT GEAR; PENNSYLVANIA R. R.

The Pennsylvania R. R. now has in its freight equipment about 10,000 steel hopper-bottom coal cars of 50 tons capacity, most of which are equipped with the Westinghouse friction buffer and draft gear. These cars are built of steel plates and pressed steel shapes. The general designs were prepared by the Motive Power Department of the Pennsylvania R. R., to which we are indebted for copies of the plans, and the cars are built by the Pressed Steel Car Co., of Pittsburg, Pa. A comparison of these cars with some others of the same class built by the same firm for other railways is given in the table below.

The general plans showing the construction of one of these cars are given in Fig. 1. There are four pressed steel sills of channel section, 10 ins. deep at the ends and 17 ins. at the middle. These sills are riveted to end sills of Z section, the short upper vertical leg being riveted against the end posts, while the deeper vertical leg is slotted out

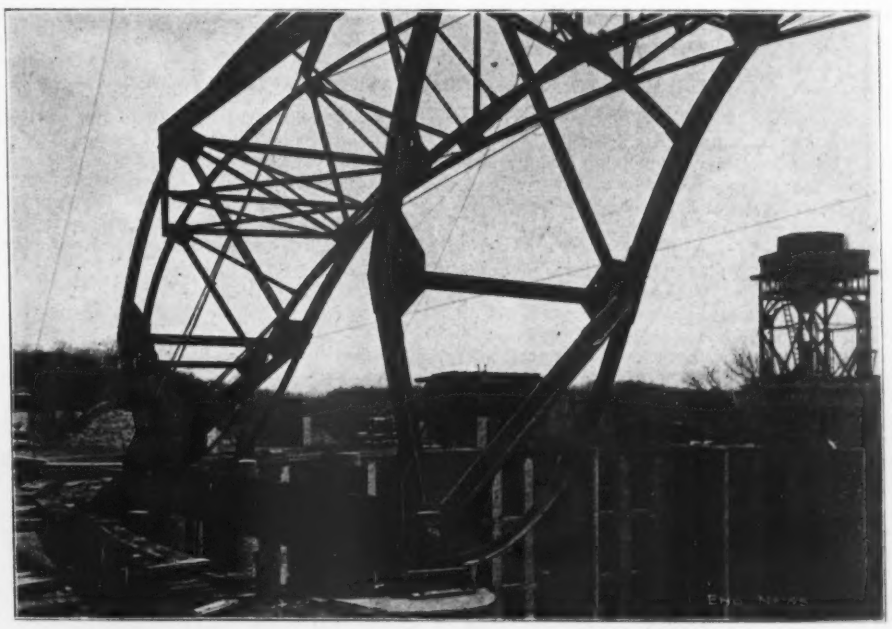


FIG. 4. VIEW AT HEEL OF ARCHES DURING ERECTION.

	100,000-lb. Hopper-Bottom Coal Cars; Pressed Steel Car Co.									
	Great Northern Ry.		Ches. & Ohio Ry.		L. S. & M. S. Ry.		Balt. & Ohio Ry.		Pennsylvania R. R.		Erie Ry.	
Length inside	30 ft.	0¼-in.	28 ft.	0¼-in.	30 ft.	0¼-in.	30 ft.	0¼-in.	31 ft.	6⅛ ins.	30 ft.	0¼-in.
Width inside	8 "	8½ ins.	9 "	6 ins.	9 "	6 ins.	8 "	8½ ins.	9 "	6 "	9 "	6 ins.
Height, rail to top	10 "	7½ "	11 "	1 9/16	10 "	0 "	10 "	7½ "	10 "	0 "	10 "	0 "
Height, rail to hopper		10 "		2 "		10 "		10 "	1 "	0 "		10 "
Wheelbase, truck	5 "	6 "	5 "	7 ins.	5 "	7 "	5 "	7 "	5 "	6 "	5 "	7 "
Wheelbase, total	27 "	3 "	25 "	4 "	27 "	4 "	27 "	4 "	28 "	9 "	27 "	4 "
Capacity (level full)	1,500 cu. ft.		1,920 cu. ft.		1,680 cu. ft.		1,590 cu. ft.		1,685 cu. ft.		1,680 cu. ft.	
Weight, empty	37,900 lbs.		37,700 lbs.		36,000 lbs.		36,700 lbs.		39,300 lbs.		36,300 lbs.	

for the drawbar. The body bolsters are composed each of a pair of 10-in. pressed steel channels, set back to back and riveted between the sills. The sides and ends are of flanged plates, the upper flange taking the place of a stiffening angle, while end. The wheels are 33 ins. diameter and the axles have journals 5½ × 10 ins. The truck wheelbase is 5 ft. 6 ins. The contact surfaces between the spring plank and column castings are ground to ensure a good bearing. The brakes are hung reaction force exerted by draft springs wh... m-pressed. The friction gear allows the dra... a total travel of 2 7-16 ins. in either direction... a force of 140,000 lbs. on the drawbar is req... to give it this full travel. Through the fi...

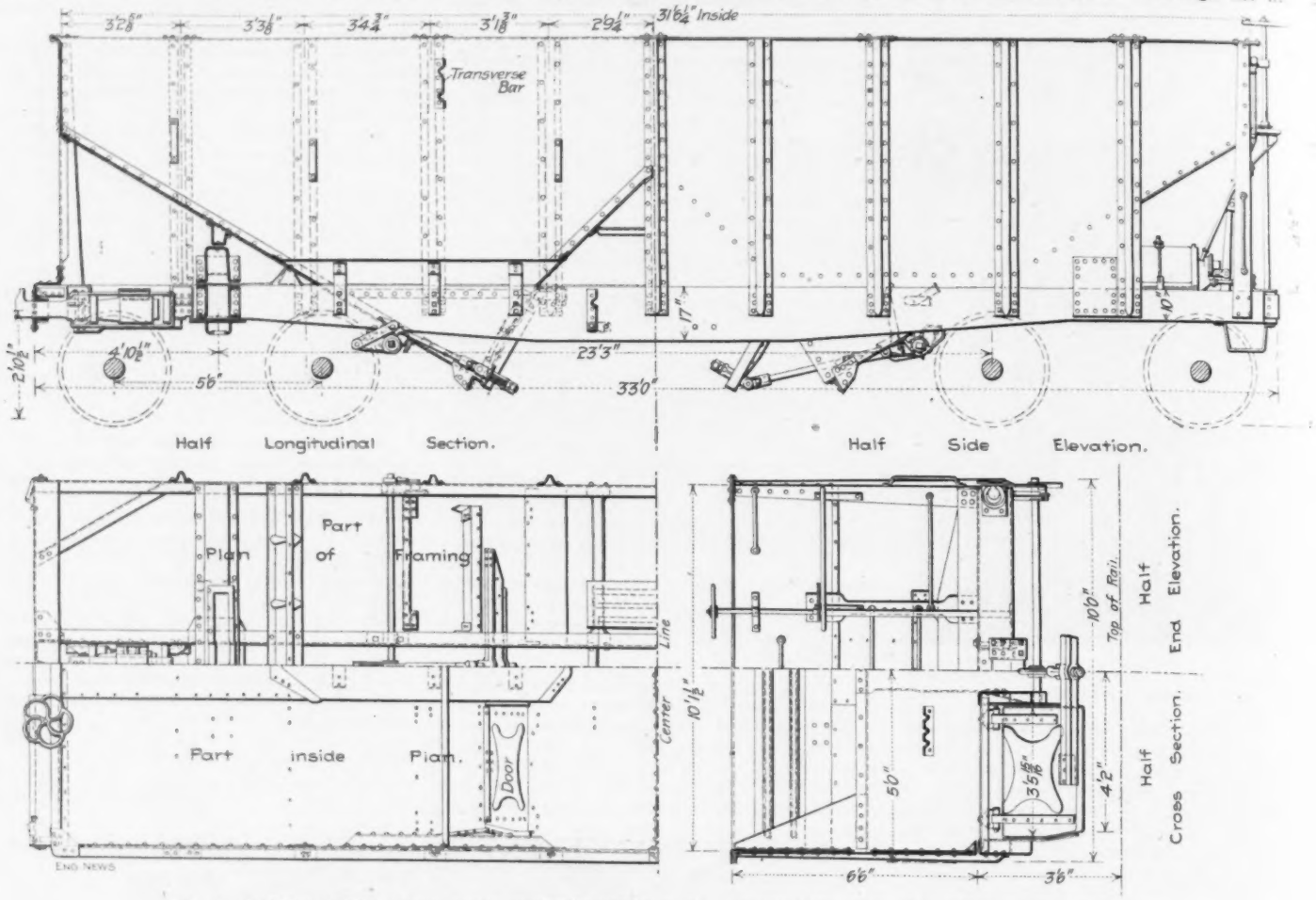


FIG. 1. 50-TON STEEL COAL CAR; PENNSYLVANIA R. R. Pressed Steel Car Co., Pittsburg, Pa., Builders.

the lower flange of the side plates rests on the flange of the side sill and is riveted to it. Transverse bars inside prevent buckling, and the sides are stiffened by pressed steel stakes riveted to the sill, side plate and top flange. The corner posts, floor plate supports over the bolsters, hopper doors and various minor parts are all of pressed steel. There are two hoppers, each with two doors 3 ft. 6 ins. wide and 2 ft. 4½ ins. deep, operated by a system of levers on a shaft 2¼ ins. square. When the car is loaded, the body settles about 13-16-in. below its level when empty. The clearance allowed between the side bearings of new cars of this class is from ¼-in. (minimum) to ⅝-in. (maximum).

These cars are mounted on four-wheel trucks with arch-bar or diamond frames and pressed steel bolsters, as shown in Fig. 2. The arch bars are 1¼ × 5 ins. and the tie-bar is ⅝ × 5 ins. The bolster is of box section, 7⅝ ins. deep at the ends, where it rests on the springs, and 15⅞ ins. at the middle. The spring plank is a steel channel, with a seat for the nest of springs at each

Dimensions of 100,000-lb. Steel Coal Cars; Pennsylvania R. R.

Length over end sills	33 ft. 0 ins.
Distance between bottom of hoppers	9 " 2 "
Length inside	31 " 6¼ "
Width over top flanges	10 " 1½ "
Width inside	9 " 6 "
Height, rail to top of body, light	10 " 0 "
" " " bottom of hopper, light	8¾ "
" " " top of sills, light	3 " 6 "
" " " center of drawbar, light	2 " 10½ "
Depth at hopper	9 " 0 "
Depth at ends	2 " 6⅝ "
Wheels, diameter	2 " 9 "
Trucks, wheelbase	5 " 6 "
Trucks, distance c. to c.	23 " 3 "
Cubic contents, level full	1,672 cu. ft.
Marked capacity	100,000 lbs.
Weight, empty	39,300 "
Weight, loaded, level full	139,300 "
Live load, level full	71.79%
Dead " " "	28.21%
" " per ton of capacity, level full	786 lbs.
" " per cu. ft. of capacity, level full	23.5 "

between the wheels, and the bolts securing the brake-hanger support to the spring plank have double nuts and are riveted over upon the nuts.

The Westinghouse friction draft gear with which these cars are fitted is a device which Mr. George Westinghouse invented and patented some years ago, in which the frictional resistance de-

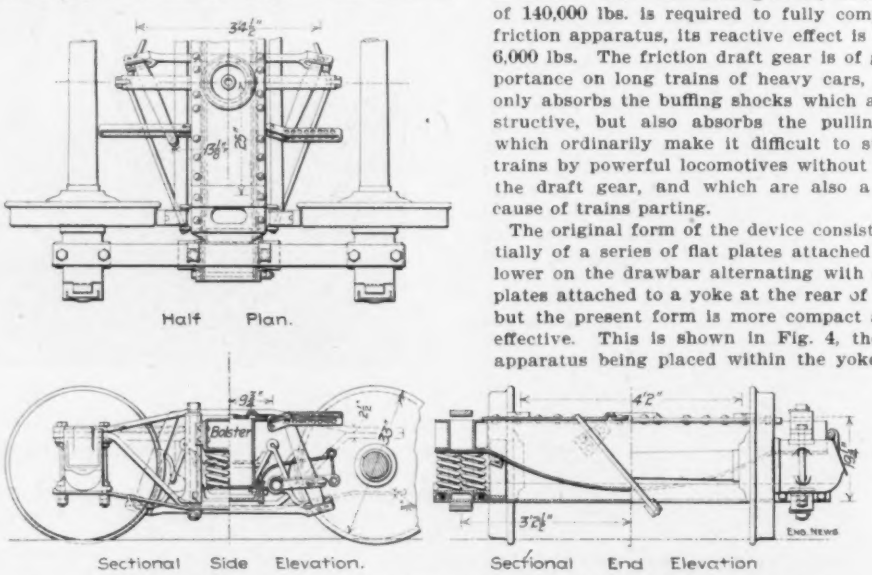


FIG. 2. TRUCK FOR 50-TON COAL CARS; PENNSYLVANIA R. R.

veloped between sliding surfaces was utilized to absorb the shocks of buffing and pulling. This device not only takes up a much greater proportion of the force exerted upon the coupler than ordinary draft springs, but is also free from the

of the stroke the resistance is due to an ordinary spiral draft spring, which provides the requisite elasticity for ordinary operation, but through the remainder of the stroke there is an ever increasing frictional resistance, combined with spring pressure, that takes up the effect of heavy strains or blows. With this arrangement, while a force of 140,000 lbs. is required to fully compress the friction apparatus, its reactive effect is less than 6,000 lbs. The friction draft gear is of great importance on long trains of heavy cars, as it not only absorbs the buffing shocks which are so destructive, but also absorbs the pulling shocks which ordinarily make it difficult to start such trains by powerful locomotives without injury to the draft gear, and which are also a frequent cause of trains parting.

The original form of the device consisted essentially of a series of flat plates attached to a follower on the drawbar alternating with other flat plates attached to a yoke at the rear of the yoke, but the present form is more compact and more effective. This is shown in Fig. 4, the friction apparatus being placed within the yoke and be-

tween the followers in the usual way. The ... of the drawbar may be made to fit the yoke, ... shown in the longitudinal section, or, if the or... nary form of drawbar is used, filler pieces ... placed above and below to fill in the space ...

ween the drawbar and yoke where they are iveted together, as shown in the smaller drawng of the yoke.

At the back of the yoke is the follower plate A, gainst which bears the coiled spring C, the front nd of which bears against a conical wedge D, of ctagonal section, with a hard brass shoe or plate n each face. Built up around the wedge are ight malleable iron carriers E; each of these has a segmental outer face, with a longitudinal stiffning rib, which acts as a guide, while the inner face has a projecting seat N to fit one face of the wedge. The ribs of these carriers are of triangular section, and fit within alternate grooves F in the friction cylinder B, the head of which bears against the front follower Z. The other grooves in this cylinder are fitted with wedge bars G, having lugs H which engage with pockets in the segmental carriers E, so that as the carriers are moved in either direction the bars move with them.

The back follower spring A receives the pulling stresses from the end of the yoke; the front follower Z transmits them to the drawbar stops and to the car framing. The function of the spring C is to force the wedge against the inclined surfaces N of the segmental carriers, and also to absorb the ordinary pressure on the drawbar due to the movement of the train. When the apparatus is placed in the yoke, this spring is under a slight compression, which insures the parts being held tightly in position, thus preventing foreign substances from lodging between the bearing surfaces. The small auxiliary concentric spring O gives additional pressure on the wedge. The main release spring K is used for returning the segmental carriers and wedge bars to their normal position after the force to close them has been removed, and it also gives additional capacity to the device. The function of the release auxiliary spring L is to release the wedge D, and the release pin M relieves the pressure of this auxiliary spring against the wedge during frictional operation.

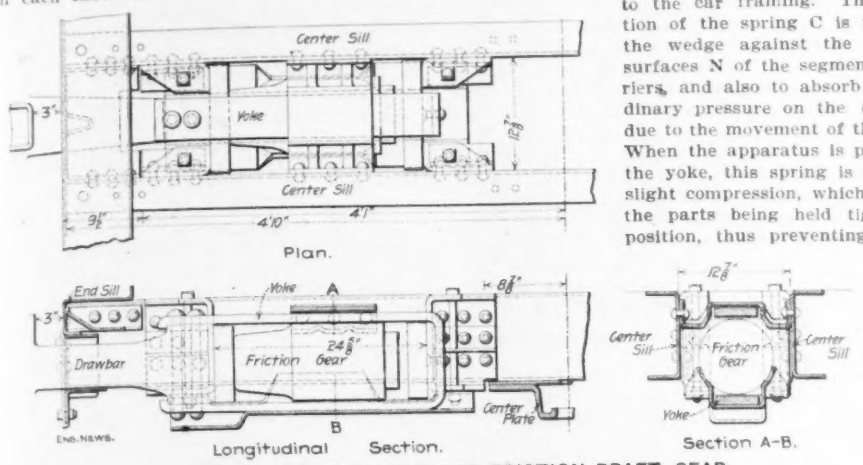


FIG. 3. DRAFT RIGGING FOR FRICTION DRAFT GEAR.

The operation of the device is described by the Westinghouse Air Brake Co. as follows:

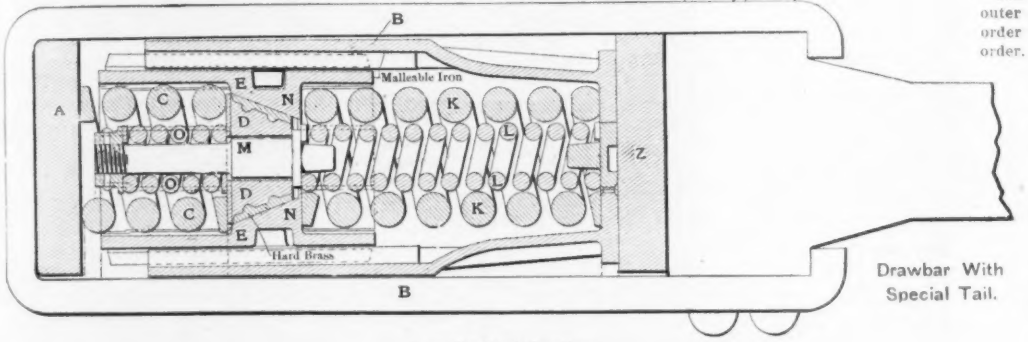
When, either in draft or in buffing, the stress upon the drawbar moves the follower plates, A or Z, toward each other, the preliminary spring, C, is compressed, and if the pressure so applied is less than is required to force the follower plate, A, against the release pin, M, the segmental carriers and wedge bars remain at rest. The capacity of this spring is about 20,000 lbs. and is sufficient to provide for a large percentage of the drawbar movements, thus greatly relieving the frictional element from motion and consequent wear. When, however, the stress exceeds the capacity of the preliminary spring sufficiently to push the follower, A, against the ends of the segmental carriers, it will have forced the release pin, M (which projects slightly above the segmental carriers), toward the closed end of the cylinder, thereby relieving the pressure of the auxiliary release spring against the small end of the wedge. In this position the force necessary to compress the springs, C and O, is exerted against the large end of the wedge, and by the inclined surfaces it is transmitted through the segmental carriers and wedge bars into motion, and in so doing the force exerted by the wedge upon the wedge bars produces friction between the wedge bars and the V-shaped grooves of the cylinder (which is tapered toward the closed end). The traverse of the wedge bars is completed when the follower, A, comes in contact with the end of the cylinder, the release springs, K and L, having been compressed to about 80% of their capacity. The complete movement of both spring and frictional elements result in a total resistance of about 140,000 lbs.

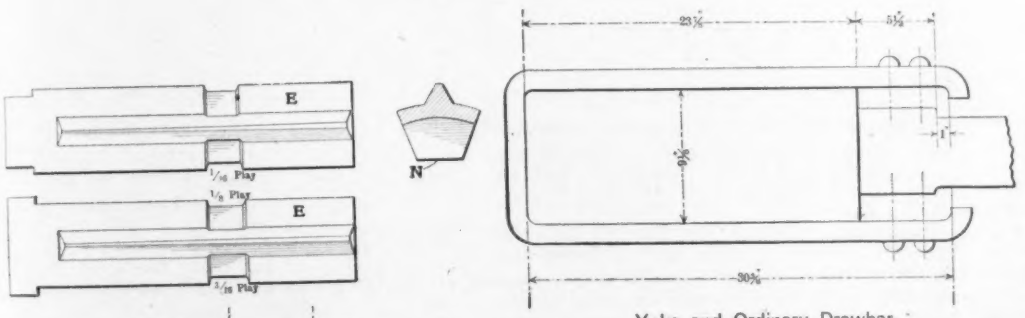
On the removal of the pulling stress at the coupler, the springs, C and O, return gradually to their normal length. The preliminary release spring, L, then pushes the wedge back and away from the segmental carriers, and in this condition the main release spring, K, bearing upon the projections, N, of the segmental carriers, presses them to the left, which, when accomplished, withdraws all of the wedge bars from their positions in the grooves at the small end of the cylinder, constituting a complete release of the friction device.

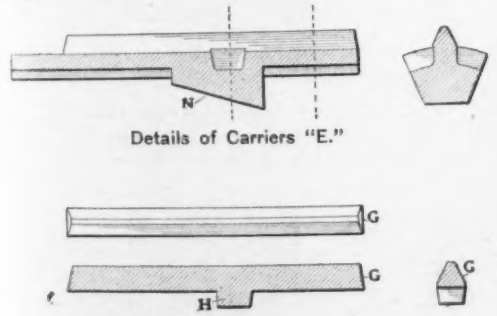
The carriers, E, are arranged in pairs with interlocking outer ends (as shown in the plans of these carriers) in order to prevent them from being put together in wrong order. Each carrier contains two of the loose wedge bars, and the slots in the carriers in which the lugs of the wedge bars engage are of different lengths. In a set of two bars the first lug fits the slot, the second has $^1/_{16}$-in. play, the third $^1/_8$-in. play, and the fourth $^3/_{16}$-in. play, as indicated. This is also clearly shown in the four sections of the wedges and carriers fitted together. It will thus be clear that under the influence of the spring K the top one of these wedge bars will be released first, and the others in succession as the space in the slots is taken up. Four bars are represented by each section; when those at the top are released the spring K releases four more, represented by the next section below, and so on. Since there are eight carriers in all, or four sets of two each, it is only necessary for the spring K to release the wedge bars four at a time until all are free.

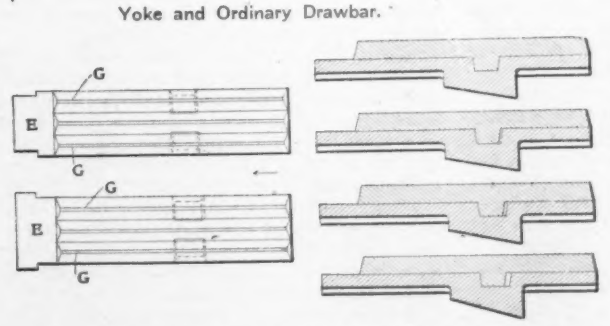
The operation of buffing is exactly similar to that of pulling, in that the follower plates are moved towards each other, but the load comes first upon the outer follower in this case. The application of the spring and friction resistances and the manner of fractional release are the same for pulling and buffing.

Numerous tests have been made by railway companies adopting this device, and show uniformly satisfactory results in work accomplished and in low cost for maintenance. The most significant results, however, are those obtained in regu-









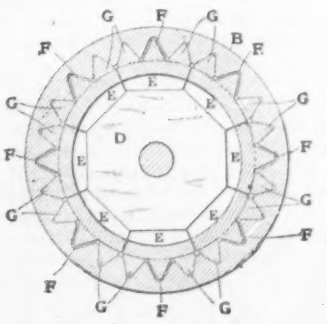


FIG. 4. WESTINGHOUSE FRICTION DRAFT GEAR. Westinghouse Air Brake Co., Pittsburg, Pa., Makers.

lar service, and these indicate the value of the friction gear in absorbing the force of heavy shocks, thus not only preventing the parting of trains, but relieving the draft rigging and car framing from the racking and destructive effects of these shocks. Up to the present time the Westinghouse Air Brake Co., of Pittsburg, Pa., has applied the friction draft gear to about 41,000 freight cars and 1,400 engines.

THE BASE LINE MEASUREMENTS FOR THE 98TH MERIDIAN TRIANGULATION.

By John F. Hayford.*

The author has been led to prepare the following article for the perusal of engineers by the feeling that it would be of especial interest to them as a record of the most rapid and economical measurement of bases of a primary degree of accuracy that has yet been made. For the line measures required by the engineer, usually of a lower degree of accuracy than those here described, it is believed that much simpler and quicker methods will be secured by dropping out some of the refinements of the primary methods rather than by elaborating the methods of the land surveyor or the city surveyor. Cases to illustrate this point might be cited from recent engineering literature. To the student of the progress of science and engineering this campaign of primary base measures will be interesting because it was planned and carried out in the spirit of the engineer rather than of the scientist, whereas in the past the reverse has been true as a rule. The engineer accepts past experience as his working material, decides upon the results which it is desired to secure, and then selects such methods as will secure those results with the minimum expenditure of time and money. The scientist, accepting the same heritage as the engineer, is apt to select his plans with reference primarily to enlarging the domain of exact knowledge and with little regard to the energy required to do so. The season of primary base measures herein described was one of accomplishment rather than of experiment.

Nine primary bases were measured during the latter half of 1900 by a party under Mr. A. L. Baldwin, of the Coast and Geodetic Survey, to whose zeal and ability the marked success of the season is mainly due. These bases are to serve the purpose of controlling the lengths on a portion of the 98th meridian triangulation which will, when completed, stretch from the Canadian border on the north, at the Dakota line, through North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Indian Territory and Texas to the Rio Grande. The Mexicans are at work on a triangulation which will be an extension carrying this southward to about latitude 17°, the point at which the 98th meridian intersects the Pacific coast. This triangulation, together with the transcontinental triangulation along the 39th parallel, each bisecting the country, will form the main framework or control for all surveys in the United States. Of the nine bases the Page Base at the north is in Nebraska, almost within sight of the Dakota line, and the Alice Base in Southern Texas is within 120 miles of the Rio Grande. These bases, together with the Salina Base on the transcontinental triangulation, will control the lengths on 1,100 miles of the 98th meridian triangulation.

Within the limit of this article it will be possible only to set forth the principal features of the work, laying emphasis by selection on the most important, and to call attention to departures from past practice.†

GENERAL PLAN OF THE WORK.

The usual past practice in regard to primary base measures has been to measure one base at a time as the necessity for it was developed in the course of the triangulation. The measurement of the base, together with the necessary preparation and standardization of apparatus before and after the measurement has frequently occupied a base party for a whole working season. It was decided at the outset that in the measurement of the bases along the 98th meridian the wholesale instead of the retail plan would be followed, the bases being measured in advance of the triangulation in part. Aside from the general advantages of the wholesale over the retail plan in all operations, it was confidently expected that the unusual skill which would be acquired by a party making measurements of several bases in quick succession would help greatly in increasing the speed and reducing the cost of measurement. It was evident also that a considerable saving in cost, with no loss of accuracy, would be the result of making but two standardizations serve for nine bases.

An examination of the manner in which errors of length accumulate in a triangulation in passing from a base to a remote triangle side shows clearly that the most accurate part of the operation is the base measurement; that the accumulation of error is most rapid in passing from the base to the border lines of the base net, since poor geometric conditions are necessarily encountered in

Fig. 1. Sketch Map Showing Location of Base Lines Measured During 1900 for the 98th Meridian Triangulation.

the expansion from the base; and that the errors of length accumulate more slowly in the chain of triangles between base nets than in the base nets, but that even here the errors are large in comparison with those involved in the base measures. It is evident, supposing the accuracy of the angle measures to remain unchanged, that the average accuracy of the lengths in a triangulation may be considerably increased by placing the bases at shorter intervals. On the other hand, it is evident that increasing the accuracy of the base measures will have but little effect on the average accuracy of the lengths.

Along the 98th meridian the average interval between bases was therefore made short, a little more than 100 miles upon an average, in marked contrast to the average interval of over 250 miles on the transcontinental triangulation.

The base being the strongest portion and the base net, or expansion from the base, being the weakest portion of the triangulation, it is evident that it is good engineering practice to strengthen the base net at the expense of the base. Accordingly the reconnoissance party selecting [illegible] for bases was instructed to pay especial attention to securing good geometric conditions in the base nets, even at a sacrifice of accuracy in the bases, and was informed that the accuracy of the base measures could be kept up to the required standard on any grade not exceeding 5%, and that narrow, deep ravines or valleys should not be considered obstructions to the base measures. Under these instructions the tendency was therefore to secure rough bases in good base nets.

As the sole function of measured bases is to control the lengths in the triangulation, the value of any proposed increase in accuracy in the base measures is to be determined from the increase in the average accuracy of the lines of the triangulation thereby produced.

A study of the results of previous triangulation in many localities shows that the errors due to the angle measures are always much larger than the errors of the base measurement, even in the immediate vicinity of the base. It was evident that very little increase in the average accuracy of the lengths of the lines of the 98th meridian triangulation would result from increasing the accuracy of the base measurement beyond that represented by a probable error of one part in 500,000, even to the extent of making the base measurement absolutely perfect. To try to increase the average accuracy by reducing the errors of the base measurement beyond the limit indicated would be about as effective as trying to decrease the elongation of a chain under a given tension by increasing the size of certain links which were already from two to ten times as large as the smallest links. The orders under which the base party operated stated the limits of accuracy on each part of the work necessary to keep within the degree of accuracy indicated by a probable error of one part in 500,000. The party was then ordered to strive to keep as far within these limits as possible by the use of good judgment and skill, but was ordered to restrict the time and money expended upon each operation substantially to that required to keep barely within these limits. Experimenting to secure a higher degree of accuracy was then positively prohibited. The party was encouraged to neglect precautions known to be unessential to the degree of accuracy sought.

ORGANIZATION OF THE PARTY AND THE BASES MEASURED.

The base party of eleven persons, three experienced and two inexperienced officers of the regular staff of the Survey, one recorder and five laborers, reached Shelton, Neb., on July 16, 1900, no preparation whatever having been made at that point in advance, the party equipment being still at the railway station. During the next 31 days the party built a field comparator, standardized all the apparatus upon it, measured the Shelton Base, 7.9 kilometers (4.9 miles) long, and traveled to the next base at Page, Neb. The party was then reduced to ten persons, and was continued throughout the season at that size, except that occasionally extra laborers were hired for a short time. On Jan. 18, 1901, the departure of the party from the last base began. In six months a working party of ten had standardized all the base apparatus twice, had measured nine bases, having an aggregate length of 69 kilometers (43 miles), and had incidentally traveled and transported their complete equipment more than 1,600 miles by rail. Deducting the time spent in traveling, the average stay at each base was less than 16 days, not excluding Sundays and holidays.

Fig. 1 shows the location of the bases and the railways used by the party in transit. The order

Name of base and state.	Length, m.	Probable error, mm.	Probable error as proportional part.	Date of arrival of party.
Shelton, Neb.	7,884.72	± 9.0	1/876000	July 16.
Page, Neb	8,250.99	± 5.6	1/1473000	Aug. 16
Anthony, Kan.	6,034.70	± 4.8	1/1257000	Sept. 10
El Reno, Okla.	12,886.68	± 9.7	1/1329000	Sept. 27.
Bowie, Tex.	8,198.04	± 5.0	1/1639000	Oct. 22.
Stephenville, Tex.	6,255.08	± 6.0	1/1042000	Nov. 7.
Lampasas, Tex.	5,961.13	± 4.1	1/1454000	Nov. 20.
Alice, Tex.	6,971.69	± 10.1	1/690000	Dec. 7.
Seguin, Tex.	6,794.61	± 5.1	1/1333000	Dec. 21.

Beginning of departure from Seguin Base, Jan. 18, 1901.
The average probable error of the nine bases is 1 part in 1,200,000.

*Inspector of Geodetic Work, Coast and Geodetic Survey, Washington, D. C.

†For a full account of these base measures, comprised in 73 4to pages, see Appendix No. 3 of the Coast and Geodetic Survey Report for 1901, entitled: "On the Measurement of Nine Bases Along the Ninety-eighth Meridian." This Appendix may be obtained by applying to the Superintendent of the Coast and Geodetic Survey.

f measure of the bases, as well as other infor-nation, is shown in the table at the bottom of he preceding page.

The total cost to the Government of measuring hese nine bases, including the standardization f apparatus and including all freight and trans-ortation beginning and ending with Washington, ll new equipment purchased, pay of both men nd officers, the office computation and the prep-ration of the report for the printer, was $11,075, 1,230 per base, or $160 per kilometer ($260 per nile). In comparing these with other statements f the cost of base measurement care should be aken to ascertain whether the contrasted state-ent includes all the items here enumerated.

MEASURING APPARATUS AND METHODS OF WORK.

In so far as the writer is aware there is no ex-eption to the rule that whenever a base has been measured with two different types of apparatus, liscrepancies between the measures have devel-ped which were too large to be consistent with he degree of accuracy which was supposed to be ttainable with each apparatus. All of the evi-dence available indicates that each type of ap-paratus, and possibly each particular apparatus even of one type, should be suspected of being subject to an error peculiar to itself. In planning the base measures of 1900 it was determined at the outset that five sets of apparatus of two dif-ferent types, namely, four steel tapes and a bar apparatus, should be used. Unless the error pe-culiar to each of these sets of apparatus happens to be of the same sign, which is unlikely, it is obvious that there will be a partial elimination of their individual errors on each base. Two of the steel tapes were 100 meters long and two 50 me-ters long. The bar apparatus was that known as the Eimbeck Duplex Bar apparatus, the same that was used on the Salt Lake Base in Utah in 1896. The instructions to the base party required that all five sets of apparatus should be used on each base; that one kilometer of each base, to be known as the test kilometer, should be measured with all five sets; that the remaining sections of the bases should each be measured twice; and that upon an average one-fifth of these remaining measures should be made with each apparatus.

A study of past base measures furnished abundant evidence that one frequent source of constant errors peculiar to a given apparatus has been the usual practice of standardizing, or determining the length of, the apparatus under one set of conditions, and then using it in the field under a different set of conditions. The most serious errors are apparently those due to er-roneous determinations of the temperature of the measuring bar or tape. To obtain the length of a steel bar or tape within one part in a million it is necessary to determine its temperature within less than one-tenth of a degree centigrade. In general the temperature of the measuring bar or tape cannot be ascertained with certainty within this degree of accuracy by any of the methods or-dinarily used, namely, by mercurial thermometers near to or in contact with a steel tape at night, mercurial thermometers near to or in contact with a measuring bar, or by the difference of ex-pansion of two tapes or two bars placed side by side and assumed to have the same temperature. There is abundant reason to believe that the er-rors in temperature to be feared are dependent upon whether the apparatus is in sunlight, shade or darkness; subjected to rapidly rising, falling or stationary temperatures; whether exposed to wind or fully sheltered from it; whether it is in-side a building, shed or yard, or fully exposed in open fields. Accordingly the base party was re-quired to standardize the base apparatus in the field under conditions approaching as closely as possible in every respect to those encountered dur-ing the base measurement proper. As the stand-ardizing was to be done on the first and last bases, and as it was expected that all the ap-paratus would be in use and subject to the vicis-situdes of transportation and camp life for several intervening months, it was desirable to obtain some check on the constancy of length of each ap-paratus. This check was furnished in the form of the intercomparison of the lengths of the five sets of apparatus resulting from the measurement of the test kilometer on each base.

The iced bar used, Fig. 2, in standardizing the base apparatus was designed by Prof. R. S. Wood-ward, and first used by him on the Holton Base. It is a steel bar 5 m. long, carrying a micro-scopic graduation on platinum plugs set in its neutral axis, supported in a Y-shaped iron trough in such a manner as to be kept straight both horizontally and vertically while it is almost sur-rounded by melting ice and in contact with it. There is no appreciable uncertainty as to the temperature of the bar under these circumstances. All experiments made with it indicate that within a few seconds after the ice is placed upon the bar it reaches a constant temperature which is inde-pendent of external thermal conditions. The length of this bar had been previously deter-mined at the Coast and Geodetic Survey Office by direct comparison with the National Prototype Meter No. 21, which is in turn a duplicate of, and has been compared directly with, the International Meter, preserved at the International Bureau of Weights and Measures near Paris.

Each of the two field comparators consisted es-sentially of two stable stone monuments, each car-rying a spherical-headed bolt which served to limit the distance of approximately 100 meters which was to be accurately determined; a row of 6 × 6-in. posts set slightly to one side of the line at 5-m. intervals to be used as microscope sup-ports; and a line of posts to serve as track sup-ports set on the line, but midway between the microscope posts. The apparatus brought from Washington for the comparators consisted of three sections of portable track used to support the iced bar, five micrometer microscopes with their mountings, and the iced bar and its appur-tenances. In measuring the distance between the centers of the spherical-headed bolts the initial bolt was first referred to an optical line held by the first microscope directly over it and nearly above it by the use of a piece of apparatus known as a cut-off cylinder. The measuring then pro-ceeded from one end of the comparator to the other by steps of five meters, the micrometer mi-croscope readings upon the opposite ends of the iced bar in any given position being taken simul-taneously by two observers. The measurement was then referred from the last microscope down to the bolt by the use of a cut-off cylinder. The only systematic error of which there is any trace in the results is that due apparently to a change in the relative temperature of the two sides of the microscope mounting when an umbrella is placed over it after it has been exposed to the sunshine. This error is small and reverses its sign but not its magnitude when the direction of progress of the measurement is reversed. To eliminate it each measure was always followed immediately by another in the reverse direction and the mean of the two was considered as form-ing one measure. The range of five such double measures made on the Shelton comparator at the beginning of the season was 0.14 mm., or one part in 700,000, and the corresponding range of three measures on the Seguin comparator at the end of the season was 0.22 mm., in each case showing a much higher grade of accuracy than was abso-lutely required.

The length of each of the five sets of apparatus was determined by measuring the 100-m. com-parator interval with it under conditions as nearly as possible like those encountered in the regular base measures, including the method of support and manipulation of the apparatus, and including in the case of the tapes even the use of the same spring balance to determine the tension. For the purpose of imitating the base conditions as nearly as possible each comparator was built in the open air with no protection whatever from the sun and wind, each being located in an open pasture. No difficulty was encountered in securing super-abundant accuracy in the standardization, the probable error of length of each piece of apparatus being easily brought below one part in a million. No conclusive evidence was found that any ap-paratus had changed its length during the season.

FIG. 2. VIEW SHOWING MANNER OF USING ICED BARS IN MEASURING A BASE LINE.

FIG. 3. VIEW SHOWING MANNER OF USING DUPLEX BARS IN MEASURING A BASE LINE.

Each unit of the duplex base apparatus consists of two 5-m. measuring bars of steel and brass, respectively, mounted near each other and side by side within the same double tubular brass case. Three thermometers are so placed as to have their bulbs at the same height as the bars and midway between them. The bars are used as contact measures on tripods, or so-called tres-tles, as indicated in Fig. 3, a photograph taken at the moment when approximate contact was being made between the front and rear bar, the front bar being aligned by the use of a small telescope mounted on its forward end, and a pair of tripods were being placed in position ahead of the front bar. The two bars within each case are so mounted that the two measurements with steel and with brass proceed almost independently, the steel of the front unit being brought into contact with the steel of the rear unit at each movement, and the brass with brass.

The effect of the unequal coefficients of expan-sion of the two metals is to make the brass, with the greater coefficient, gradually get ahead of the steel if the measurement is made at high tem-perature, or to gradually fall back if the tempera-ture is low. This gain or loss is allowed to ac-cumulate, or, strictly speaking, its accumulated value is measured, for a whole section of the base, 500 to 1,000 meters, and is an accurate measure of the mean temperature of the two bars upon the assumption that the mean temperatures of the two bars are the same. The mean temperature of either bar may also be assumed to be that shown by the mercurial thermometers placed between them. Thus there is obtained for a single

passage of the bars over a section of the base three values of the length of that section which may be called brass, steel and duplex, respectively. The bi-metallic principle of combination of two bars with different coefficients of expansion, for the purpose either of determining the temperature or eliminating its effect, is not new. It has been in use for many decades. The combination of the bi-metallic and the thermometric method of determining the temperature in a single apparatus, and the simultaneous use of the two methods, is a new departure, however, in so far as the writer is aware, dating from the first use of the duplex apparatus in 1896. This apparatus furnishes an unusually fine opportunity to study temperature errors, since it can be shown that it is impossible for the three simultaneous measures to agree exactly unless the true temperature is exactly determined. An examination of the results at the close of the season brought out certain peculiar relations between the three simultaneous measures with this apparatus, which can only be accounted for upon the supposition that the principal errors of measures were due to erroneous determinations of temperature. Thus one more link was added to the long chain of evidence that temperature errors are more serious than those of any other class in base measurement. All the errors, including these temperature errors, were, however, well within the desired limit of accuracy. As no conclusive evidence was found as to which one of the three results was most affected by these temperature errors it was necessary to take a mean of the three for each section. The relative weights given to the three results were derived from the agreement on forward and back measures of each section of each result with the corresponding one of its kind, namely, brass with brass, steel with steel, and duplex with duplex. The proper relative weights were found to be for the duplex 10, steel 5, brass 2. On 22 sections, with an average length of 543 m., the greatest disagreement between the forward and backward measure was for the duplex 4.2 mm., steel 9 mm., brass 12.1 mm., and in each case about two-thirds of the measures agreed within 2 mm., corresponding to one part in 270,000.

It is interesting to note that whereas the duplex base apparatus was used by its designer on the Salt Lake Base under a movable tent which protected it completely at all times from the direct rays of the sun, it was used during this season fully exposed, its only protection being the tight-fitting canvas jacket which had always been upon it. A considerable saving in time and cost was thus made and the reduction in accuracy proved to be slight.

The average speed of measurement with the duplex bars on the last base was nearly double that on the first base. The average speed for the whole season was 53 bars per hour, and the best record made was 100 bars in 60 successive minutes, or one-half kilometer per hour. On the one base previously measured with this apparatus the ordinary speed was 40 bars per hour and the maximum speed 70 bars per hour.

The 50-m. and 100-m. steel tapes were about 6 mm. wide and ½ mm. thick (¼-in. and 1-50-in.). They were used under a tension of 15 kgs. (33 lbs.), and were supported at intervals of 25 m. The tension was applied with an ordinary spring balance mounted on a lever. The rear end of the tape was held with a light crowbar. The temperature of the tape in each of its positions was determined by two mercurial thermometers tied with their metal backs against the tape about one meter from each end of the tape within easy reach of the observer. This is a more convenient method of manipulating the thermometers than to use them to determine the air temperature near the tape, and is also believed to give greater accuracy. All tape measurements were made at night, Fig. 4.

The preparation for tape measures consisted of clearing out the line to a sufficient extent to allow of convenient measurement, of setting marking stakes in proper alinement and height at the points where the tape ends are to come, and tacking on the copper strips upon which the exact position of the tape graduations are to be recorded, and the placing of intermediate support stakes in proper alinement and with the supporting nails in their sides at the proper height.

The working party for the 50-m. tapes was made up of one observer at each end, one recorder, one man to apply the tension with a spring balance at the front end, and one to hold the tape in position at the rear, and at least one extra man to help in handling lamps and carrying the tape ahead. Two more extra men were used to good advantage when they were available. With the 100-m. tapes at least three extra men were necessary and seven could be used to advantage. The complete measuring party was thus from six to eight with the 50-m. tapes and eight to twelve with the 100-m. tapes.

There were 46 sections, each as a rule about 1 kilometer long, of the nine bases which were each measured twice with the tapes. On 60% of these sections the difference between the two measures was not greater than 2.5 mm., or one part in 400,000. The greatest difference was 9.6 mm., or a little less than one part in 100,000.

The speed of measurement with the steel tapes at night showed a decided increase as the party gained in skill, especially with the 100-m. tapes. The average speed of measurement during the season with the 50-m. tapes was 1.8 kilometers (1.1 miles) per hour, and the maximum speed during any one night was 2.1 kilometers (1.3 miles) per hour. The average speed for the season with the 100-m. tapes was 2.1 kilometers (1.3

Fig. 4. View Showing Rear End Arrangement of Tapes in Determining Their Length by the Shelton 100-M. Comparator.

miles) per hour, and the maximum average speed for a night was 2.7 kilometers (1.7 miles) per hour, on the Lampasas Base on November 27th, when four kilometers were measured in but little more than 1½ hours. Under ordinary conditions with either tape more than one-third of the time of the party was spent in walking forward with the tape, and during the most rapid measures more than one-half the time was so spent. The figures here given represent the speed of measurement after all preparations have been made. The setting of the stakes is the slow and costly part of tape measurement, occupying from two to six hours per kilometer for a party of four or five persons. When this preparation is included it is still found that the tape measurement is very much more rapid than the bar measurement, the average for the season being 7.1 days of work for one man to make a double tape measurement of a kilometer as against 19.5 days for the bar apparatus, or in other words, the tape measure is 2¾ times as rapid as the bar measurement. In making this comparison the work which is necessary with either type of apparatus, namely, traveling between bases, pitching camp, clearing out the line of the base, putting up and alining a few range poles, etc., has been neglected. Although the two kinds of measurement differ so much in rapidity and cost the accuracy of the results secured with the two types of apparatus is about the same.

The experience of this party indicates that hereafter it is desirable to use 50-m. rather than 100-m. tapes. The degrees of accuracy attained with the two lengths of tape are almost identical, the slight difference being in favor of the 50-m. length. The time required for setting tapes is about the same for the two. The fact that the rate of measurement proper is about 20% greater with the 100-m. than with the 50-m. tape is much more than offset by the fact that the minimum number of men required to operate the 100-m. tape is eight, while six can operate the 50-m. tape.

The use of both the tapes and the bars on grades which had previous to this season been supposed to be unsafe was not found to introduce any unusual errors. No grading was done on any of the bases. The intermediate supports of the tape were freely set above the grade of the marking stakes at the ends whenever a more convenient height of stake would be so obtained, or grading avoided. Both theory and practice indicate that this procedure does not lower the degree of accuracy appreciably, provided, of course, that the height of every tape support is determined. The intermediate supports must not, however, be set below the grade of the marking stakes. Many short grades of over 5% occurred during the measurement, and the maximum grade of the season was 3.15 ms. on a span of 25 ms., or 13%.

In view of the past experience in base measures it was no surprise to find evidence of constant errors peculiar to each apparatus in this season's work, even though special precautions had been taken against such errors. On the nine test kilometers, each measured with every apparatus, the measures made with the bars alone were upon an average one part in 175,000 shorter than the mean of all, and those with one of the 100-meter tapes were on an average one part in 385,000 longer than the mean of all. The results from the other three sets of apparatus fall close to the mean on an average. As each base depended upon the five sets of apparatus in about equal degrees it is believed that the remaining error in the final length of each base must be very small, presumably smaller than on the typical base of the past on which but one apparatus was used, and on which no conclusive evidence of the magnitude of the constant errors is available.

The average probable error of one part in 1,200,000 for the nine bases is computed from residuals which include the effects of the errors peculiar to each apparatus, whereas the probable error usually given with a base length depends simply upon the power of the given apparatus to reproduce its own measurements. This fact should be borne in mind when judging of the accuracy of the measurements during the season of 1900.

TESTS OF VARIOUS PAINTS ON THE 155TH ST. VIADUCT, NEW YORK CITY.

In September, 1897, the viaduct carrying 155th St. over the station tracks of the Manhattan Elevated R. R., in New York city, was painted with a number of paints of different composition and manufacture, with a view of determining their comparative protective qualities and durability when applied to metal subjected to the action of locomotive gases. The portion of the viaduct which was painted crosses three tracks and two station platforms, and consists of 17 lattice girders spaced 9 to 10 ft. apart and having a clear height of about 13 ft. above the rails. The lattice girders carry floor beams, to which were riveted trough floor sections, carrying the roadway. Previous to applying the paint the metal work was thoroughly cleaned by a sand blast, and the priming coat was put on immediately after cleaning. The method of cleaning the metal work was described in Engineering News of Sept. 23, 1897. On April 12, 1898, Mr. Henry B. Seaman, M. Am. Soc. C. E., examined the structure to determine the manner in which the paints had withstood the test. The results of Mr. Seaman's examination were published in Engineering News of July 7, 1898, and in the succeeding issues of July 21 and 28 and Aug. 4 and 18 there were published comments and criticisms on these results by various persons. In December, 1901, Mr. Seaman made a second examination of the paints and the results were reported in the New York "Evening Post," from which we reprint them as below. In explai-

nation it may be noted that the numerals which precede each paragraph refer to the position of the girder, counting from the north side of the bridge.

(1) Lead, graphite, and lucol oil.—Buckle plates fairly good, some not so good as others, all of them rusted, however. South side of girders and braces badly rusted; worse than north side. Bottom worse than top on both upper and lower girders. Braces badly rusted. Rust is flaky. Where rust appears, paint seems to be rotten. Some I-beams in fairly good condition; others very badly rusted. Under flange over east track badly rusted. Western half about same condition as eastern half of girder. Paint non-elastic.

(2) Graphite and linseed oil.—Does not look or have the nature of graphite paint. Does not polish when rubbed. North side of upper girder, upper flanges badly rusted, under flanges not so much. Rust very active where it appears. Buckle plates very bad and very rusted. Both north and south side the same. On the eastern half the rust is very active and deep, coming off in big scales. Buckle-plate bolt holes north of eastern half leaking. Small water pipe comes through, and water spreads on buckle plates and I-beams. Top flange of upper girder dry and paint rotten. Under flange of lower girder over eastern track very bad.

(3) Red lead, antoxide F, antoxide D.—Entirely perished. Red lead on this girder has not protected the metal. Rust too bad to classify. Under flange of lower girder over eastern track completely rusted.

(4) Graphite.—Looks like stove polish. Rust similar to girder No. 1. Upper flanges badly rusted, especially edges and rivet heads. When this paint comes off it comes off badly—very crumbly. Entire lower side of I-beam has no paint on at all. Under flange over eastern track badly rusted, large cake having recently dropped off. Buckle plates both east and west badly rusted.

(5) Nobrac.—Elasticity of paint best of all, rolling up into strings under points of spatula. Buckle plates badly rusted, upper flange of girder also rusted. Buckle plates, where intact, are in excellent condition. Elastic cement between plates in good condition, and has protected the metal thoroughly. Rivet heads show some rust. Bolt holes of buckle plates constantly leaking. Good deal of paint, also good deal of rust, on buckle plates. Under flange of lower girder over eastern track is in very good condition, but shows some rust.

(6) Carbon black.—Elasticity good. Buckle plates have less rust than girder from No. 1 to No. 5, inclusive. Upper flanges, cross and vertical braces badly rusted. Rivet heads badly and deeply rusted. Rust crumbles readily under the fingers. On eastern half a peculiar condition is found, as one buckle plate is badly rusted, while the adjacent one is in good condition. Under flange of lower girder over eastern track somewhat rusted.-

(7) Durable metal coating.—Slightly elastic. Breaks under spatula. Where there is rust it is deep. Buckle plates, I-beams, and plates corroded. Paint is pimply. Upon scraping where apparently good, rust is found beneath, indicating a varnish formation under which rust travels. Under flange lower girder over eastern track very bad.

(8) Black manganese iron.—Perished. Detailed inspection not possible.

(9) Carbonized coating.—Has elasticity, but not so much as either No. 5 or No. 6. More hard than elastic, but apparently has clung well. Buckle plates, upper flanges, and braces show smaller per cent. of rust than any of the others from No. 1 to No. 8. Where rust does appear, it is of the active sort. On the eastern half over the track. buckle plates, girders, braces, etc., are very badly rusted. Under flange of lower girder on this side very bad.

(10) Mineral rubber.—Has no life. Rusted badly, deep and rotten over entire girder, braces, and plates. Over eastern track very bad.

(11) Graphite.—Graphite like stove polish. Entire girder, buckle plates, etc., badly rusted. Over eastern tracks bad.

(12) Carbon.—Elasticity excellent. Buckle plates, flanges show some rust, but in better condition than any of the others, except under flange directly over eastern track, where it is somewhat rusted.

(13) Graphite.—Rust spreads over the entire surface. Rust active under the paint that shows. Over eastern track bad.

(14) Graphite.—Buckle plates, braces, girder badly rusted on western side. On eastern half better condition apparently, but rust is active under the paint. Surface of eastern half looks befter than any other eastern half except that of No. 12. Lower flange over track freely rusted.

(15) Asphalt.—Very dry; no life; breaks easily under spatula. Very badly rusted. Rust very rotten and deep. Worse on upper flanges and I-beams. Directly over eastern track very bad.

(16) Rubberine.—Apparently like coal tar. Seems to be tough, but has no resisting power. Rust rotten. Very pimply. Very active. Over eastern track it is very bad.

(17) Black Diamond.—Not so elastic as other carbons. This girder is in worse condition on north or inside than on south or outside. Buckle plate badly rusted, also north side of girder. South side pitted. Over eastern track very bad. Two connecting water pipes in structure at this point are in extremely bad condition, owing to action of water.

Mr. Seaman summarizes the results of his studies as follows:

The carbon and graphite paints have lasted altogether better than any of the other kinds that were applied on the viaduct, the carbon paints being rather better than the graphite. In my opinion, carbon paint is the best material to withstand the sulphurous fumes of locomotive gases.

Red lead did not really have a fair test. It was used on several of the girders, but it was not applied by a manufacturer of red lead, but by the makers of other paints, who wished to use red lead in connection with their own. It might have given better results if it had been tried on its own merits. It forms a sort of cement which makes it effective for resisting moisture, as on ship bottoms, but it does not withstand the gases from coal so well. Asphalt and the compounds of rubber have lasted very poorly.

A PUMPING PLANT FOR RAISING CONDENSING WATER TO AN ELECTRIC POWER STATION.*

By Charles Hopkinson.†

The condensation of steam in the large quantities required in electric power stations is often a difficulty in those cases where a central site is selected. Even if economy does not demand condensation, public policy does. The discharge of aqueous vapor in large quantities is intrinsically and legally a nuisance. This objection has caused trouble to users of cooling towers, and was the reason for abandoning a cooling tower scheme as part of the Newcastle tramway power plant.

As an alternative, it was decided to pump from the River Tyne, distant some 500 yds. horizontally and 86 ft. vertically from the engine house, and to utilize the energy of the water flowing back to the river. The first idea was to use reciprocating pumps and water pressure motors directly connected, the loss in the system being replaced by motors supplied with electric energy from the power house. The usual course of advertisement and specification failed to elicit any suitable offer of reciprocating plant from contractors, and the centrifugal pump and turbine arrangement offered by Messrs. Mather & Platt was adopted, and the author believes that the arrangement may be found interesting in itself and possibly useful as a precedent.

The system is designed to supply at present 75,000 gallons per hour, and to be conveniently capable of expansion to supply from 150,000 to 200,000 gallons per hour, as developments may require. The general arrangements are shown in Fig. 1.

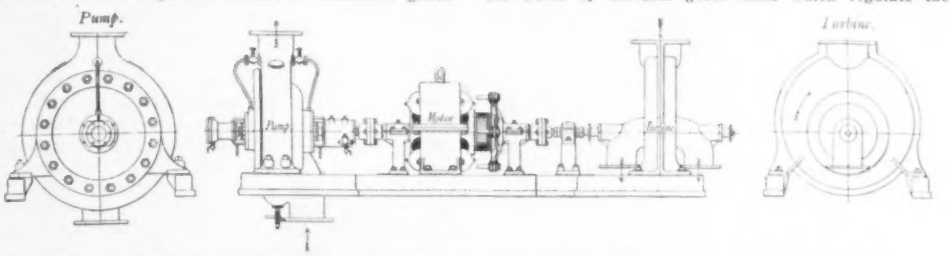


FIG. 1. GENERAL ELEVATIONS OF PLANT FOR CIRCULATING CONDENSING WATER, NEWCASTLE ELECTRIC RY. POWER STATION.

The plant consists of three Mather & Platt single-chamber high-lift centrifugal pumps, driven by shunt wound motors and assisted by Gilkes' "Vortex" turbines on an extension of the pump and armature spindle. In these pumps the water enters the revolving wheel (23⅝ ins. diameter) axially, symmetrically on each side of the wheel, so that axial thrust is eliminated; the water then traverses the curved internal passages between the vanes, and is discharged tangentially at the periphery into a stationary guide ring of special construction. This ring is concentric with the revolving vanes, and conveys the water to an annular chamber in the body of the pump, where the velocity head imparted to the water by the wheel is converted into pressure head. The turbine consists of a brass wheel 13½ ins. diameter surrounded by a supply chamber, from which the water is directed onto the wheel by movable guide-vanes which regulate the flow to the wheel. After traversing the vanes of the wheel towards the axis, the water is discharged symmetrically on each side of the wheel. It will thus be seen that the construction of pump and turbine is the converse each of the other.

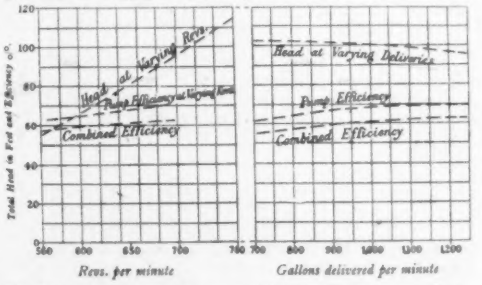

Total Head in Feet and Efficiency %
Head at Varying Revs.
Pump Efficiency at Varying Revs.
Combined Efficiency
Revs. per minute

Fig. 2. Tests at Constant Delivery of About 1,250 gallons per min.

Fig 3. Tests at Constant Speed of About 700 R. P. M.

Figs. 2 and 3. Diagrams Showing Results of Tests of High-Lift Centrifugal Pump Driven by Direct-Connected Electric Motor.

(Head includes a suction of about 15.5 ft.)

The pipes have been put in of sufficient size to pass the ultimate supply with a moderate loss of head. Two 15-in suction pipes are provided, each available for the service of either of two pumps. The pumps deliver into a main 24 ins. bore rising to the power house, from which branches are taken to each surface condenser. The return water, collected in a similar main laid in the same trench, has branches to each turbine and a by-pass direct to the tail pipe of the turbines.

It is evident that under varying conditions of head the efficiency and duty will be somewhat variable. Tests were therefore made both with and without the auxiliary turbines at the makers' works, suction and delivery heads being obtained by throttling and the output measured over a notched weir. The accompanying tables and curves show the principal results.

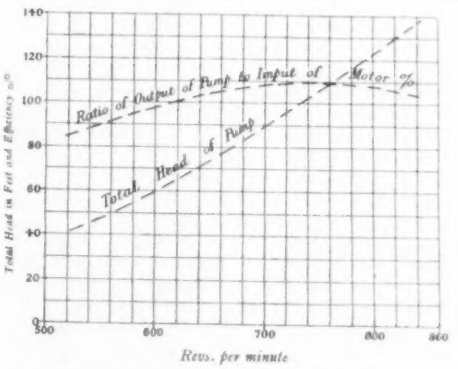


Fig. 4. Tests of Motor, Pump and Turbine Combined at Constant Delivery of About 1,250 gallons per min.

(Average Head on Turbine is about 1 ft. less than Delivery Head on Pump, or about 9.3 ft., dess than Head shown on Curve. Average Constant Suction on Pump = 8.3 ft.)

A comparison of Figs. 2 and 4 shows that the addition of the turbine reduces the power required in the ratio of 108 to 62—a saving of 42.6%—about half of the saving theoretically possible with perfectly reversible mechanism. In estimating the efficiency of the whole combination, it must be remembered that the loss of head in the pipes, and valves and condensers, is constant with a given flow, and that the head so lost is not available for the restoration of power in the turbine.

*A paper read before the Institution of Mechanical Engineers.

†Wernetts Chambers, 29 Princess St., Manchester, Eng.

THE KAZUSA SYSTEM OF ARTESIAN WELL-BORING IN JAPAN.

A recent issue of the "Indian and Eastern Engineer," of Calcutta, describes the "Kazusa," or artesian well-boring methods as practiced in Japan. By simple and cheap appliances the Japanese bore wells 960 ft. deep through earth and sand; and a Japanese syndicate lately put down a trial boring for oil 1,200 ft., half of it in hard rock. The Chinese use a similar method in the Province of Sze-chuan, in boring for oil; and some of these Chinese wells are 1,800 ft. deep and from 5 to 6 ins. diameter.

The Japanese well-borer works under a contract stipulating—no water no cash; and his en-

tire plant costs about $100, and is for the greater part made by himself. His gang is composed of five men, including himself, and a boy to run errands. The necessary scaffold is made of 6-in. round timbers lashed together with rice-straw ropes; and he puts this scaffold up in about one hour. On it is then mounted a reel, with two sets of spokes made of 6 to 8 planks 14 ft. long, 6 ins. wide and about 1¼ ins. thick. In the center of each plank a hole is cut 1½ ins. diameter, and through this hole is passed an iron shaft 4½ ft. long. The sides of the reel, at the center, are kept from coming together by running the shaft through a hollow bamboo; and the ends of the shaft rest on strong and firmly braced posts, and are held in place by a U-shaped iron driven over them. The outside ends of the planks are kept opposite to each other by pieces of wood, let in crosswise, each 3 ft. long, 3 ins. broad and 2 ins. thick; and to keep the planks spaced two bands of bamboo strips are passed around the reel and firmly lashed to the cross pieces.

The first hole is dug, 8 to 12 ft. deep, by a narrow spade, gouge-like in form, 6 ins. across, and provided with a long wooden handle. After this hole has been sunk, a long, hollow bamboo, not less than 4 ins. inside diameter, is carefully inserted in the hole and plumbed. About one foot of this cylinder projects from the ground, and around this another short tube or box, about 18 ins. across, is placed. The boss-borer then sits on a stool opposite this box, facing the reel, and here issues all his orders, always keeping one hand on the bamboo boring-rod to keep in touch with the boring.

The gang lifts the boring-rod from 12 to 18 ins. at a time and then let it fall; the weight of the tool and the connected rods usually do the work, though the boss sometimes gives it a strong downward push. The boy every now and then pours a few buckets of water down the hole as the boring proceeds; and in sandy soil this water is mixed thick with clay so as to line the hole made and keep it in better shape. For soft rock, clay or gravel the cutting or boring tool is an iron or steel chisel let into a shaft of hard wood, usually teak wood. This shaft is about 12 ft. long and 2½ ins. diameter; and it is coupled to the bamboo rod by a hook-shaped scarf with two iron rings driven over the ends. The cutting tool is simply a piece of iron or steel secured to the teak stick by two iron tongues held by two iron rings.

The tool for removing the debris from the bore is a 3-in. iron tube about 8 ft. long; at the bottom is screwed on a short length of tube of greater diameter expanded to a bell-shape, and across this is fitted a steel chisel projecting slightly from the bell. This chisel, or chopper, prevents the debris from forming balls. Immediately above the chisel is a valve opening upwards; and about 5 ft. up the tube is a square-cut hole, 3 ins. long by 1½ ins. wide, to permit the air and water to escape and also to facilitate emptying. At the top of the tube is a bar of wood, riveted fast to the tube, and extending down to the opening mentioned, and this bar is provided above with a scarf for coupling to the bamboo rods. Any excess of water in the hole is removed by a similar but lighter bailing tube.

The bamboo rods are really strips of flexible bamboo, from 10 to 20 ft. long, 1½ ins. wide and ¼ to ½-in. thick; they are joined by a simple but strong wedging scarf held by three iron rings, or bands. Such a bamboo cable is strong and supple, and is yet stiff enough to permit an effective downward stroke when the boss deems this necessary. To wind up this cable one of the men steps into the reel, and treads it around by stepping from one cross piece to another, steadying himself by putting his hands on the side planks; every joint is carefully examined as it comes up and defective pieces are removed or repaired.

When the water-bearing strata is tapped and the hole cleaned out, a series of bamboos are joined together into a pipe and lowered to the bottom; 30 years is considered an average life for this pipe. These bamboos are joined by selecting the same size as nearly as possible; and then cutting the end of one length into four projecting separate slips with inside projections on each slip; the second length has four holes cut in it corresponding to these projections. The second length is then inserted into the first; the projections pressed into their slots, and a coarse, fibrous paper is wrapped around the joint and tied by stout strings made from palm tree fiber. Well made, this joint is stronger than the rest of the bamboo pipe.

As the bamboo-cable will sometimes break, a sort of grapnel is used made of iron and having a strong iron ring sliding down over the sharp, barbed ends. This tool is fastened to the bamboo-cable; but before being inserted in the well the ends of the grapnel are brought somewhat close together by a string that is not too strong; and this same string ties the heavy ring up near the top. This is to prevent the ends of the grapnel from splaying out and catching in the sides in going down. Upon getting in touch with the broken bamboo the boss commences making gentle prods at it until he thinks it is well within the "graspers;" this action breaks the string and also permits the iron ring to descend and force the barbs into the bamboo. This is work requiring patience, but the broken piece is almost always secured..

The writer of the article says that one of these artesian wells, costing from $10 to $12, will water three acres of rice fields. A well 960 ft. deep through sand and clay, costs 500 yen, or say $250, and was sunk in four months. A 300-ft. well is usually put down in from one to two weeks.

A GRAPHICAL METHOD OF COMPUTING SWING BRIDGES.

At the meeting of the American Society of Civil Engineers on November 20, 1901, a paper entitled "A Graphical Method for the Solution of Stresses in the Continuous Girder, As Applied to Draw-Bridges," was read by Mr. Geo. F. Barton. In discussing this paper, Mr. C. H. Lindenberger gave a method of graphically investigating swing bridges of equal arms and constant moment of inertia. This method, which is a deduction from the three-moment formula for concentrated loads, is quite short and simple, and may often be used with convenience. We therefore reprint it in slightly modified form, from the "Transactions of the American Society of Civil Engineers," Vol. 48, p. 89:

The following graphical method was devised by the writer over ten years ago, and described by him before the Franklin Institute. The original articles* dealt only with the most general case, and many parts are difficult to understand on account of that fact. The present brief summary is restricted to a girder resting on four supports, with equal end-arms and constant moment of inertia. It is a method of constructing the actual equilibrium polygon for the actual loads, so that reactions, shears and moments can be at once scaled from the drawing. No quantity needs to be computed analytically; but well-known methods of computing certain factors graphically are omitted here, for obvious reasons.

A bridge as specified is represented diagrammatically in Fig. 1, resting on the four supports S_1, S_2, S_3, and S_4; its spans are l, r l and l, respectively. The first step is to find two points which will be called the "fixed points,"

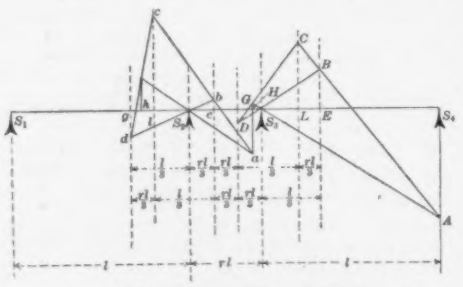


Fig. 1. Method of Finding "Fixed Points;" A Graphical Method of Computing Swing Bridges.

H and h in Fig. 1. The construction for finding them is shown in the figure. The distances S_2 L, L E, L D, S_2 e, S_2 g and S_2 l are laid off as shown, by using the quantities $\frac{l}{3}$ and $\frac{r\,l}{3}$. Then, taking S_4 A and L C any convenient length, draw in succession the lines A C, B D, D C and A G, which gives the point H on the vertical line G a. Similarly, lay off H a and l c any convenient lengths, and draw a c, b d, d c, and a S_2; intersection of the latter line with d c gives the at h. The points H and h are the "fixed points" It may be proved that

$$S_2 H = \frac{r^2 l}{2 + 3r},$$

and

$$S_2 h = \frac{2 (1+r) l}{3 r^2 + 10 r + 6}.$$

The further construction is shown in Fig. 2. T span carries loads P_1, P_2, etc., as shown; k l is

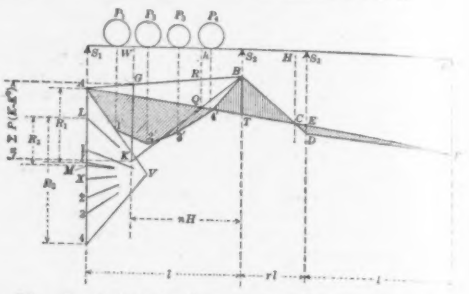


Fig. 2. Determination of Equilibrium Polygon.

tance from any load to the end support S_1. Draw the force-polygon A—4 for these loads, and with any pole V construct the equilibrium polygon A—1'—2'—3'—4'—B, as if the end arm S_1 S_2 rested simply on its end supports and was disconnected from the remainder of the bridge. Now, compute Σ P (k — k²), either graphically or analytically as it will be convenient to use this value to a larger scale than that of the force polygon, the value found should be multiplied by n, an arbitrary multiplier. If the perpendicular from the point V to the line A—4 be called H, we find n H and lay it off as S_2 W. The vertical through W intersects the line A B at G, and from G downward lay off G K equal to the previously determined value of n Σ P (k — k²). Draw K B, which intersects the vertical through the 'fixed point" h at Q. Then the straight line A Q F is the closing line of the true equilibrium polygon for the continuous girder in question. The line A Q intersects the vertical through H at C, and by drawing B D and D F the equilibrium polygon is completed.

The reactions are found by drawing lines from the pole V parallel to the sides of the new equilibrium polygon. Thus I A = R_1; L 4 = R_2; L M = R_3, and M I = R_4. The shears and moments can now be scaled directly from the diagram.

The proof for the construction may be found in the original articles in the "Journal of the Franklin Institute," already referred to. The method of treatment of a pivotal bridge of equal arms will be evident from the foregoing, as only one fixed point need be found.

*Published in the "Journal of the Franklin Institute," November, 1889; January, 1891, and March, 1891.

SIMPLE AND RAPID TESTS FOR CEMENT.*

The engineer of a small city will seldom have time or outfit for the complete cement tests now usual on large works, for which there are needed a special man with an expensive equipment installed in a separate room.

The following described simple tests can be made by the engineer himself, with an outfit costing not over $4, and which can be stored in a desk pigeonhole. The tests thus made will be interesting in themselves, and will be effective and convincing aids in rejecting most bad cements which may be offered, and will also have the preventive effect of causing manufacturers to send their lower grades of cement elsewhere and to send only their best products to the places where such tests are probable:

(1) FOR FINENESS.—Sift three to four ounces of cement through a standard test sieve of 100 meshes per linear inch. Reject cement of which 10% by weight is retained on the sieve. This is conservative, and the limit may be made smaller, for many Portland cements are now in the market which will leave less than 4%. A test by 200-mesh sieve, with a 30% limit, is desirable, but takes time.

(2) FOR QUICKNESS OF SETTING.—Make a pat of 4 oz. of neat cement, adding one-quarter to one-fifth its weight of water and making a putty-like ball which can be dropped on the table and retain its form without falling to pieces. Press this upon a 3 × 4-in. glass plate, leaving it ½-in. thick in the center and sloping to thin edges all around. Note time required to take initial set. Reject cement which sets in less than 25 minutes. It may take three hours or more, but it will be better for paving if it sets in one hour. The instant of "initial set" is determined by noting when the surface will support a 4-oz. weight resting upon the smooth flat end of a 1/12-in. diameter wire.

(3) FOR SOUNDNESS.—Use the pat on glass above described and note when it sets enough more to make it difficult to indent it with the thumb nail, or when it will

*From the new edition of "City Roads and Pavements Suited to Cities of Moderate Size," by William Pierson Judson, M. Am. Soc. C. E. Reprinted by permission of the author.

upport 1 lb. on the smooth flat end of a 1/24-in. wire, hich may be considered as indicating "a hard set." hen put the pat with its glass plate over boiling water ntil the steam has heated them, and then immerse and eep them in the boiling water for three hours. Reject ortland cement if the pat shows radiating cracks in the nter, or shows blow-holes on the surface, or curls up om the glass, or cracks at the thin edges. Good natural ments may fail to endure this test (which is a severe ne), and it may properly cause the rejection of some ortland cements which would endure it after being air-slacked" or "seasoned."

(4) FOR PURITY.—Provide a glass-stoppered bottle of uriatic acid, two shallow white bowls or two ½-in. × in. test tubes, a glass rod and a pair of rubber gloves. ut in a bowl or a tube as much cement as can be taken n a nickel 5-ct. piece; moisten it with half a teaspoonful of water; cover with clear muriatic acid poured lowly upon the cement while stirring it with the lass rod.

Pure Portland cement will effervesce slightly, and will ive off some pungent gas and will gradually form a right yellow jelly without any sediment.

Powdered limestone or powdered cement-rock mixed with the pure cement will cause a violent effervescence, he acid boiling and giving off strong fumes until all the arbonate of lime has been consumed, when the bright ellow jelly will form.

Powdered sand or quartz or silica mixed with cement will produce no other effect than to remain undissolved s a sediment at the bottom of the yellow jelly.

Reject cement which has either of these adulterants.

Powdered slag mixed with cement unfits it for pavement work. The adulteration is indicated in the dry ment (when coloring matter does not conceal it) by a lilac tint, and it is also indicated on the surface of a test-pat after drying by brown and green and yellow discolorations.

A chemical test will show the presence of slag if made as follows: Provide an ounce of mixture of methylene iodide ($C H_2 I_2$) and benzine, in which the methylene (the specific gravity of which is 3.³⁹², being the heaviest organic liquid) is reduced to the specific gravity of 2.⁸⁵ by addition of benzine. The methylene is uncommon and costs $1 an ounce.

Into a ½-in. test tube put ½-in. of the dry suspected cement and pour in a little of the mixture, stirring to a thin grout. Then cork the tube and let it stand. If slag is present, it will remain at the top, while the cement will settle to the bottom. The separation cannot be seen if coloring matter is present.

Coloring matter in any cement will show itself in the acid test by giving a black or gray color to the resultant jelly, which would otherwise be yellow. The coloring matter may or may not be injurious in itself, but its presence shows that the manufacturer wished to disguise the cement, which should be rejected, because there are a plenty of good cements which need no disguise.

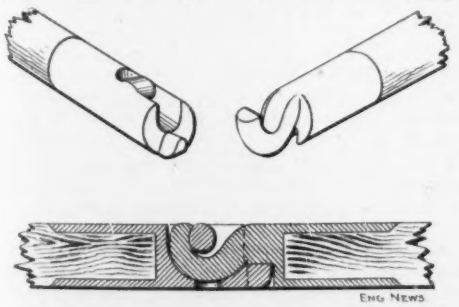
WEIGHT.—The several kinds of cement differ materially in weight, and any cement that varies much from these average weights should be examined specially.

The standard barrel contains 3.65 cu. ft., and the standard bag is one-fourth of a barrel. The average weight of a cubic foot of packed cement is: Portland, 104 to 114 lbs.; puzzolan, 90 lbs.; natural, 75 to 82 lbs. for Eastern and 70 to 72 for Western, the average net weight of each per barrel being 375 lbs., 330 lbs., 300 lbs. and 265 lbs.

RESULTS.—These tests will be conclusive as far as they go, and will cause the rejection of no good cements. The makers of high-grade cements would not object to these requirements and would not increase the price because of them.

COUPLINGS FOR SEWER CLEANING RODS.

The amount of time that is often wasted in cleaning sewers and other conduits through lack of good tools is only too well known to many



ENG NEWS

Couplings for Rods Used in Cleaning Sewers, Electric and Other Conduits.

engineers and city officials. The accompanying illustration shows a new form of coupling for the rods so frequently used in this work. The view of the two parts and longitudinal section of the coupling need no explanation, but attention may be called to the quickness with which the coupling may be made and its rigidity after the junction is effected. The device as it now stands was invented or perfected by Mr. B. R. Felton, M. Am. Soc. C. E., of Boston, at one time city engineer of Brockton, Mass. The couplings are made from either malleable iron or brass. Harold L. Bond & Co., 140 Pearl St., Boston, are agents for the device.

COMMERCIAL SUCCESS IN LONG-DISTANCE ELECTRIC POWER TRANSMISSION *

Theoretically, we could bring to San Francisco energy from Columbia, or even Niagara Falls; but this would not pay. By what equation shall we determine the permissible distance of source of power from business center? This is a most important and, as well, a most fascinating inquiry. It is easy to declare that kilowatts should cost the company only so much at the power house in order to cost the consumer so much at the place of delivery; it is a very different matter to figure out the individual factors in the equation. Look a moment at these factors.

Thus the business field—how important that it should be described accurately in your figuring as so many thousand horse-power. How much power for motors and lighting does the field now consume, and how much more can it be tempted by lower rates and probable civic growth to absorb? It is easy for enthusiasm—the wish fathering the thought—to overestimate this item. But to underrate very much will prove fatal.

Then the competition of coal, oil, gas, etc.—are the parties dealing in these commodities able to reduce their rates to meet our attacks without self-annihilation? Moreover, what competition of enterprise like our own will the situation likely arouse? The more inviting it is to us, the more inviting it will be to others. Will other long-transmission giants, big and insolent as ourselves, strive to reach the narrow gateway to success first and to crowd us out and trample us down? Must we fight with our brethren for the heritage?

Again, on what terms have we secured our capital, with what discount on our bonds, with what rates of interest, and with what fateful total of final principal some day to be paid in full? The cost of the plant is not the money paid out for labor and material, that is, the actual payment, but the par value of our indebtedness incurred.

Another factor of immense importance in our commercial equation is the depreciation of power house apparatus, pole lines, raising and lowering transformers and distributing plant. The moment construction is finished many forces begin to destroy the result—chemical disintegration, oxydizing metals, vitiating the insulating qualities of rubber, etc.—biological assault of fungus, microbe and worm—fire, rain, flood, tempest, etc. All human construction responds to the same law, and only awaits its doom from the hour of its first beginnings. What percentage on our cost of plant must we annually count off for loss? The transformer has a very brief life, the generators now made, a very long one; but sooner or later both will lie on the junk heap. Any financier or promoter who allows less than 5% on actual cost, for depreciation, will have a future sorry awakening. It will average more than 5% annually, in all probability; and ascertainment of the exact percentage is quite essential to a reducible equation of any value. No doubt this factor of depreciation is the most formidable and the most elusive. Few corporations are willing to invest a great sum of money and then calmly charge against themselves, on account of wear and tear 5 to 10% of the entire payment; and few promoters will ever be heard alluding to so disagreeable an aspect of the financial problem. Both corporation and promoter say: "Oh, let the future look out for that." And all will go well, while all is new; but when the flumes are found rotten, pipe lines bursting, insulation reduced to powder, transformers burning by the score, poles falling and water wheels antiquated, a new issue of bonds will add to the burden of the manager and threaten future solvency.

Two Irishmen tried to kill a rattlesnake, and one of them declared the creature dead. "The baste is dead intoirely." "But no, Mike," protested the other, "sure and he moves." "Be jabers," insisted the first, "the baste *is* dead intoirely, only he is not conscious of it." There are some electric companies that are dead entirely, only they are not conscious of it; some fine morning they will wake up to this fact.

The losses of energy by various resistances and counter strains in the different parts of the system are easily calculated and need only mention; they must be in the equation, but present no difficulty in calculation.

The running expenses also can be figured with considerable exactness, in view of accumulating experience.

The risk from labor troubles is not the least of the factors in our equation. Unless we can by close combination throttle this evil, we must figure largely on its bearing unfavorably upon success.

Allied to this growing menace of organized labor is the seething of the communistic tendencies of the times. Very many, jealous of capital, hostile to the ownership of franchises by private parties and indulging in visionary expectations of socialistic action on the part of the people, favor the assumption by communities of all enterprises of a public nature. Foremost among the schemes urged is that of municipal ownership of public utilities. This we need not fear, not only because manifold experience is demonstrating the inefficiency, extravagance and corruption actually attending such experiments; but also because, if they should be very generally tried, they would not menace long-distance transmission, since municipalities need our cheap power, whether they or we peddle it out to customers.

For us a far more dangerous agitation is that which now proposes state expropriation of all water rights, reservoirs and reservoir sites, and all systems of distribution of water, in the interest of complete state control of irrigation and of the sale of power derived from water. This scheme openly advocates condemnation of both water properties and wheat ranches on a method of valuation which makes the appropriation little less than sheer confiscation. Indeed this movement is simply an organization of public robbery on a large scale, is characterized by all the insolence of the communistic spirit, and is the more dangerous because its involved perils to all ownership of private property is not perceived by its adherents, and all its fallacies have not been shown up by experience. If successful this agitation will result in the confiscation of every long-transmission source of power. It does not, however, seem to be making very rapid progress; and whether, in a state where political life is so corrupt as in California, the people will tax themselves to raise millions to purchase old reservoir systems and to construct new ones, placing enormous sums of money at the disposal of their frail representatives, with danger of peculation, inefficient expenditure and only remote benefits; and whether the ranchers to be thus encouraged will prefer to their present "water lords," as we are called, their own county politicians, remains to be seen. For one, I doubt it; but the agitation is being vigorously pushed in the name of progress. We need to exercise vigilance and to be prepared to combine our forces for Boer-like tenacity of defense.

Leaving the commercial aspect of our work, we can profitably spend some of our time upon legal obligations. How can we best provide against the possible assessing of damages for accidental personal injuries by proper warnings, how defeat the meddling of the fool and the malice of the knave, how prevent the stealing of current, the abuse of flat rates, the blackmailing of pettifogging lawyers, etc., by securing new legislation, by judicially applying old statutes, by appeals to higher courts? At the last session of the state legislature the Standard Company, by a little judicious lobbying, secured an enactment making it a penal offense to mischievously or maliciously tamper with or injure transmission apparatus; and your presiding officer, with the generous help of Senator Robt. T. Devlin, of Sacramento, succeeded in securing a statute making it a misdemeanor to steel current by tapping wires or meddling with meters. These were reasonable laws and were obtained without corruption. So long as we ask only for what is just, there is a fair probability of securing the needed legislation, if not immediately, yet by exercise of a little patience and persistency.

There is also an ethical aspect to our work—yet, even if corporations have no souls. Our high-tension currents are very marvelous and pleasing to contemplate—from a distance. "Doctor," asked an inebriate, when his physician was warning him, "Doctor, you don't think that stimulants are really going to hurt me, now, do you?" "Oh, no," replied the sage, "not if you leave them alone." Our wires are perfectly harmless—if you leave them alone. A large number of persons, not all employees by any means, have, during the past year, suffered injury or died from shock; and the result has been not only a general feeling of dread, or even of hostility to our work, embarassing the securing of rights of way and menacing by damages our incomes, but also an appeal to those feelings of humanity in ourselves, which even electricians share with their kind. How to lessen the danger, how to devise new and better methods of resuscitation, etc.—all such questions we should patiently entertain and strive to answer.

THE MANUFACTURE OF LOCOMOTIVES in the United States, says the U. S. Census Bureau, now shows a capital investment of $40,813,793 in the 28 locomotive establishments. The value of the product is returned at $35,209,048; to produce this $10,896,614 was paid for wages, $1,369,341 for miscellaneous expenses, and $20,174,395 for materials. These 28 works turned out 2,774 locomotives of all classes, and 272 more were built in 26 railway shops, making a total of 3,046 locomotives, valued at $30,397,456, built during the census year of 1900. The value of locomotives has increased since 1890. The 2,409 locomotives built in the census year 1890 had an average value of $8,190, while the 2,774 built during the last decade average $9,777 in value, the increase being largely due to changes in size and design. In the census year 1900, 525 locomotives were exported.

*Extract from the Presidential address of Dr. Chas. W. Van Norden, before the Pacific Coast Electric Transmission Association.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - - PRESIDENT.
D. MCN. STAUFFER, - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
F. P. BURT, - - - TREASURER AND BUSINESS MANAGER.

WM. KENT, E. E. R. TRATMAN, M. N. BAKER, CHAS. S. HILL, — ASSOCIATE EDITORS.

A. B. GILBERT, - - - - - - - ASSISTANT MANAGER.

CHAS. W. REINHARDT, - - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston, — ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.

FOREIGN AGENTS.

C. MITCHELL & CO, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.00 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 323 means that subscription is paid to the 32d week (that is the issue of Aug. 6) of the year 1903; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The very valuable report of the British Commission on water-tube boilers for naval purposes, which we print in this issue, is likely to have a marked influence upon boiler equipment in the navies of all nations, and even on the use of water-tube boilers in the merchant service. The committee agree as to the advantages of the water-tube boiler for naval purposes, and agree also as to the difficulties and dangers which have so far attended the use of water-tube boilers in the British Navy. The solution which they finally recommend, and which has already been adopted for six new British cruisers of 22,000 I. HP., is to install a combination boiler plant of cylindrical and water-tube boilers, the former to be used for cruising at all ordinary speeds, the supply of auxiliaries, etc., and the water-tube boilers to be used only when extra speed is to be attained. In the case of the new British vessels, one-fifth the equipment, or 4,400 HP., is to be cylindrical boilers and the remaining 17,600 HP. will be water-tube boilers.

This plan is not wholly novel. It was used, for example, a dozen years ago on the U. S. monitor "Monterey." But now that the troubles with water-tube boilers in marine service are better understood, its advantages are more apparent than ever before.

The fact is that on a modern high-powered cruiser or battleship, the entire capacity in boilers and engines will be used, probably only a few hours in the whole life of the vessel. In peace there is no need for full-speed runs, save in occasional practice manoeuvers. Even in war, it will be only at rare intervals that full-speed runs will be wanted. The problem of a fleet commander in time of war will be chiefly how to husband his coal supply, and only in case of a chase will the fighting ships have occasion to show their speed. But if water-tube boilers are designed to be used only in emergencies, they can be made much lighter and more compact than the present water-tube boilers installed in battleships, which have to be made with durability and availability for continuous service as the governing requirements. They can be designed, in fact, more on the lines of the boilers used in torpedo-boat destroyers, and the saving in weight and space will be an advantage of which navel architects will take prompt advantage to better their vessels at other points.

The annual report of the Chicago & Eastern Illinois R. R., just issued, shows an increase in the average freight train load during the year that has probably seldom or never been equalled, at least by any railway company having a high average train load. In the year ending June 30, 1902, the average freight train load of revenue freight was 605.2 tons, against an average in the previous year of 487.4 tons, an increase in 1902 of 24.16%. Including company's freight, the average freight train load in the year just closed was 629.1 tons.

It will be understood, of course, that the average train load on any railway is determined by dividing the total ton mileage of freight moved by the total freight train mileage. The result will be considerably affected, of course, by the method adopted for computing the freight train mileage; for example, as to whether mileage of switching engines is included, and if so, on what basis switching engine mileage is computed. On the Chicago & Eastern Illinois, however, the report states that the total engine mileage is used for train mileage in computing the freight train load.

Bearing this fact in mind, it is quite probable that the above is the heaviest average train load of any railway in the United States. Two years ago the Chesapeake & Ohio held this distinction. It reported in the year ending June 30, 1900, an average freight train load of 488 tons, which we said at the time (Eng. News, Nov. 8, 1900) was probably the heaviest average freight train load of any railway company in the United States. Since that time, however, railways in all parts of the country have been making great advancement in the use of heavier locomotives and larger capacity cars, with consequent larger average train loads. The Lake Shore & Michigan Southern, which has long been notable for its heavy average train load, increased this average to 548.5 tons (including company freight) in the year ending June 30, 1901. Statistics for the fiscal year just closed are not available for this road, or for the other roads which are known to have high records for the size of freight trains. If any of our readers know of higher average loadings than that reported on the Chicago & Eastern Illinois, however, we shall be pleased to hear from them.

The contrast between English and American fast passenger service with respect to the weight of the trains hauled is well illustrated by the recent fast train from London to Birmingham, put on by the London & Northwestern R. R. As stated in our issue of Aug. 21, this train is scheduled to make the run of 113 miles in 1 hour and 55 minutes, or practically a mile a minute from start to finish; but the weight of the train is given as only 130 tons behind the tender, or 291,200 lbs. On the New York Central & Hudson River R. R., according to a recent statement by General Passenger Agent Daniels, the Empire State Express, which has been in service for nearly 11 years, making the run from New York to Buffalo in 8 hours and 15 minutes, has a total weight of 608,000 lbs., including engine and tender. The distance is 440 miles, and the average speed is 53⅓ miles per hour, but this includes four stops, at two of which engines are changed, and 28 slowdowns to run through towns and cities en route. For half the distance that the Empire State runs its speed is above 60 miles per hour. The speed averages on the two runs are, therefore, probably fairly comparable, so far as the difficulty of the work done by the locomotive is concerned.

It may be added that the Empire State Express is a light train, compared with many of the regular passenger trains run on roads of heavy travel. An instance of a remarkably heavy passenger train was recently related by Mr. Daniels as follows:

> A single locomotive recently hauled a passenger [illegible] of 16 cars, 9 of which were sleeping and parlor [illegible] from New York to Albany, a distance of 143 miles, in [illegible] 15 mins., which is 44 miles per hour, and is the [illegible] schedule time of this train. The train weighed [illegible] 0 lbs. and was 1,212 ft., or nearly a quarter of a [illegible]

What is the matter with the electric motor for mine hoists? It has been in use to some extent for this purpose for ten years or more. In our issue of Aug. 21 we illustrated an electric hoist used in one of the very deep shafts on the Comstock lode. Yet in a paper on another page of this issue the manager of a company which sells electric current to mines declares that, "until a simpler, better and more reliable electrical hoist is developed, he will hesitate to recommend them to a customer." We suspect that the emphasis should be placed on the last of the qualifications set forth, and that it is in point of reliability that the electric-driven hoist has failed. Whether the electrical or mechanical engineering has been at fault in the design of existing mine hoists we cannot undertake to say, but the remark above quoted should certainly tend to make engineers cautious about the adoption of electric mine hoists unless safeguarded by the most rigid specifications and guarantees.

We imagine that there are many engineers who have at times felt rather skeptical of the real value of the ultra-refined and correspondingly ultra-expensive methods which have been frequently practiced in measuring the base lines from which our government surveys are developed. To these engineers at least the description of the base line measurements for the 98th meridian triangulation, which is published elsewhere in this issue, should prove refreshing reading. The results of this work seem to warrant the conclusions, first, that this ultra-refinement of apparatus and methods is of very doubtful efficiency, and, second, that even were it efficient to the extent of perfect accuracy it would be of questionable utility in preserving continued accuracy in the extended triangulation. To some persons the innovations adopted in the work described will probably be considered highly radical ones where such important data as primary base measures are to be established, but we believe that they exemplify a species of radicalism which will appeal favorably to the practical engineer and surveyor.

To summarize briefly, the work described comprised the measurement of nine primary base lines, ranging from nearly 6,000 to nearly 13,000 meters in length, from which the great north and south triangulation system along the 98th meridian is to be developed. Arguing from the obviously sound reasoning that the skill and experience gained in measuring our base would result in a saving of time and in increased accuracy in measuring succeeding bases, it was determined that one and the same party should measure the nine bases in succession, if possible, in one season. Formerly it had been the practice to measure one base at a time, as the necessity for it arose in extending the triangulation, and to employ for the work usually a different party each time and often different apparatus. The success of the innovation seems to be shown by the results which were obtained and which are described in the article to which we have already referred.

A more interesting departure from past practice which this article records, however, was the decision to locate and measure the base lines with the object in view primarily of securing an easy and accurate development of the triangulation system rather than of securing the most precise and accurate base measures possible. The reasoning upon which this decision was founded was that experience has shown that owing to such a selection of the base line in order to secure the greatest possible accuracy in its measurement, that poor geometric conditions are necessarily encountered upon expanding the triangulation, the errors which accumulate in passing from the base to a remote triangle are large in comparison with those involved in the base measures. Stated in

another way, the most accurate part of the triangulation system under ordinary conditions is the base measurement. The base lines being the most accurate portion, and the expansion of the base being the least accurate, good engineering, as the article rightly observes, urges that the triangulation from the base should be strengthened at the expense of the base measurement. To secure this object, the base lines were located only a little more than 100 miles apart, instead of 250 miles apart, as has been the common practice. They were, moreover, so selected as to ensure good geometrical conditions in developing the triangles at some expense to the extreme accuracy of the base line measure, and finally the limits of accuracy in base line measurement were set low enough to permit the other conditions to be easily attained.

One of the most practically valuable conclusions to be drawn from the results of the work described, however, is that by using 50 or 100-meter steel tapes about as accurate results are secured as by using iron or duplex metal bars, while the tape measurement is 2¾ times as rapid as the bar measurement.

The great increase in the cost of the diamonds used in diamond drills appears to be due, not to the exhaustion of the Brazilian deposits in which these diamonds occur, but to the fact that the methods of mining are so crude as to make it impossible for the supply to keep pace with the demand. According to a recent consular report, abstracted in another column, vast deposits of the ground in which these diamonds are found are still unworked, and with proper machinery and management should prove very profitable.

We have repeatedly called attention to the absurd waste of Government funds which is going on year after year in the construction of the Hennepin Canal, from the Mississippi River, at Rock Island, Ill., to the headwaters of the Illinois River. The work has been in progress for ten years; but the canal was obsolete when it was begun. In a recent address by Mr. Jas. A. Seddon, before the Illinois Valley Association, which is agitating for the improvement of the Illinois River, we find the following pungent comment on the Hennepin Canal:

> In the district between the Illinois and the Mississippi rivers the government is now at work on a new canal, heedless of the commercial decline of the Illinois and Michigan canal, not 20 miles above it. This work is to cost some $8,000,000, and probably no one could be found to guarantee that the whole value of the through freight on it would ever reach an amount large enough to even pay the salaries of its lock-keepers.

The chief reason for the development of long-distance electric transmission plants in California far in advance of those of any other section of the country has been, of course, the very high cost of steam power there, on account of the high price of coal. This situation has been entirely changed during the past two or three years by the development of the California oil fields. It is stated that some California steam plants using fuel oil at 70 cts. per barrel are now producing power at a total cost for fuel and labor of only $34.60 per indicated horse-power per year of 313 days of 24 hours each. While this new and cheap fuel will doubtless compete successfully with electric transmission plants in cities and other points where transportation facilities exist, the electric plants have still the field pretty much to themselves in the supply of power to mines and other isolated users of power who can only obtain oil at large expense.

CONCERNING FIREPROOF WOOD—SO-CALLED.

The Insurance Engineering Experiment Station, recently established at Boston, Mass., in connection with the Boston Manufacturers' Mutual Fire Insurance Co., has just issued its first report, entitled "Fireproof Wood—So-called," and its contents are decidedly interesting.

As many of our readers are aware, "fireproof wood—so-called," has been adopted and used for decks and other wood finish in a number of the latest U. S. war vessels. Its use has been made obligatory by law for the finish of buildings erected in New York city exceeding a certain number of stories in height, and its application for these and other purposes has become so extensive during the past few years that a half dozen or more companies are now manufacturing it.

Now come Mr. Edward Atkinson and Prof. Chas. L. Norton, of the Insurance Engineering Experiment Station, and declare in substance that this so-called fireproof wood is practically worthless as a measure of fire prevention. If they are right, then a great many thousand dollars are being wasted in the purchase of "so-called fireproof" wood, and a great mistake was made in compelling the use of this wood in New York city. If they are wrong, then their errors should be pointed out, in order that no obstacle may be put in the way of progress toward better and safer construction.

Space forbids the reprinting of the complete report in our columns,* but it may be briefly abstracted as follows:

Part I. is by Mr. Atkinson, and relates that being asked to advise as to the best material for library shelving he applied to six manufacturers of fireproofed wood for samples. Most of these samples were turned over to Prof. Norton for regular laboratory tests; but Mr. Atkinson took a half bushel of blocks, chips and shavings from these samples to his country house, put them in an open fireplace and lighted them with crumpled newspapers. The mass burned with a sickly greenish-yellow flame, emblematic, we presume, of the feelings of the fireproof-wood manufacturers. It appears to have taken a considerable time—half an hour, in fact—to light the wood, but it was finally accomplished by burning newspapers beneath it, aided by a bellows; and the experimenters were rewarded by a very satisfactory open-grate fire, which continued to burn for an hour, until 9.30 p. m., when the experimenters retired for the night.

Turning next to Prof. Norton's laboratory tests, we find that he determined first the temperature at which treated and untreated wood would ignite, and found that the treated wood required less than 100° higher temperature to ignite. Next he tried the temperature to which a brass plate had to be heated in order that a sample of wood thrown on it would instantly flash or flame. Here there was less than 200° difference at most between the treated and untreated specimens.

He also found that the treated wood smoked when heated like untreated wood, and the smoke was explosive, the same as that from untreated wood, and equally liable to ignition by a flame or spark.

Tests of pieces ¾-in. square were next made in a manner similar to the tests by Prof. Ira H. Woolson, described in Engineering News of Feb. 20, the area of cross-section left unburned after exposure to a gas flame being determined. The results coincided pretty well with the results obtained by Prof. Woolson.

Next came tests by placing samples on a hot plate, which "clearly showed the tendency of treated woods to char without much flame and to extinguish themselves when taken from the plate."

Finally, Prof. Norton made a test similar to Prof. Atkinson's, described above. A mass of "fireproof" kindling was lighted by repeated burning of papers beneath it, and while it was harder to light than untreated wood, it made "a good, lasting fire," and so hot that Prof. Norton melted several pounds of lead in a ladle over it. He also built a fire of fireproof wood between two hard, dry pear sticks, 4 ins. in diameter, in an open fireplace, and burned in the fire four good-sized pieces of 1-in. board which had been fireproofed. At the end of two hours these boards were all consumed but the pear sticks of untreated wood, although all on fire finally went out after their "fireproof" associates had burned up.

Other tests are described in the report, but their results were in accord with those already described, and we may turn at once to the conclusions which the experimenters reached.

In the first place, Mr. Atkinson says that the term "fireproof" applied to chemically-treated wood is a misnomer, and tends to mislead uninformed persons. This is unquestionably correct. There is no such thing as fireproof wood, and it may be added here that the frequently advertised fireproof paints should be placed in the same category. The so-called "fireproofing" of wood consists merely in impregnating it with certain chemicals, which, when heated somewhat, retard the formation of combustible gas from the wood and also by giving off other gases hinder the ignition of such gas as the wood generates.

Prof. Norton says correctly, and his experiments unquestionably show, that fireproof wood is a good combustible. We have little doubt that careful colorimetric tests would show that treated wood had nearly or quite as great a heating power as the same wood untreated. Nevertheless, it does not follow that the fireproofing process is valueless. Anthracite coal (when you can get it!) is an excellent combustible; yet its presence does not cause fire risk. Mr. Atkinson's fire insurance company would never object to a hundred tons of anthracite on the premises of a policyholder, while a similar weight of wood or lumber in proximity to buildings would be a matter for immediate protest.

The mere fact, therefore, that pieces of fireproof wood will ignite and burn when sufficiently stimulated by the combustion of newspapers beneath does not prove fireproof wood to be valueless by any means.

We do not say this to criticise the tests of Messrs. Atkinson and Norton. Their tests were justified by the misleading name which has come to be attached to these wood-treating processes. The manufacturers were to blame when they called their product "fireproof," and well knew that it was not fireproof at all; and they eminently deserve the reproof which they receive in Mr. Atkinson's report. We may note here the further fact pointed out by Mr. Atkinson that the so-called "electric" process of fireproofing has nothing "electric" about it. Such a misuse of terms is well calculated to arouse suspicion, and merits severe condemnation.

And now let us see what value may be fairly claimed for "fireproof" wood. The tests by Prof. Norton and by Mr. Atkinson—as well as numerous other tests which have been made—show that fireproofed wood is distinctly less inflammable than untreated wood. It is slow to ignite, and when ignited burns with little flame and with a tendency to go out, if outside sources of heat are removed. Messrs. Atkinson and Norton appear to think this quality is of small value. It seems to us, however, that under certain circumstances and conditions this quality may be of very considerable value.

Fireproof wood is not fireproof—its manufacturers now admit that. It *is* "slow burning," as repeated tests have shown. In view of Mr. Atkinson's prominence in developing the now well-known slow-burning type of building construction, he must certainly admit that the "slow-burning" principle is not wholly without merit.

The fact that the chemical treatment which we are discussing only retards the spread of flame is no reason at all for condemning it. On the contrary, the most valued appliances for fire prevention at the present day are only meant to retard, not prevent, the work of fire. We cover the steel framework of high buildings with bricks and terra cotta; but if any great building were left alone to burn with its contents, the steel would gradually absorb heat despite its non-conducting covering till it would attain a temperature so great as to lose its strength and stiffness. What the fireproofing does for the steel is to retard its heating until appliances can be brought into action to extinguish the fire.

For an additional example, take the automatic sprinkler—another most excellent hobby of Mr. Atkinson's. The purpose of this device is not to extinguish the fire—it usually is only partially successful in doing this—but to hold the flames in check and retard their spread until hose streams can be brought into play.

We do not see, therefore, since the so-called "fireproofing" process does greatly reduce the inflammability of wood and retard the spread of flame upon it, why it has not a legitimate field to

*Any of our readers desiring the full report should write to the Insurance Engineering Experiment Station, 31 Milk St., Boston, for a copy.

fill. Mr. Atkinson says that a "building would be distinctly safer if no wood, treated or untreated, were used in the flooring or the finish or even in the doors," and he thinks that substitutes for wood could be used instead and the floors could be covered with incombustible material.

We fear, however, that he is not talking about the present state of the art. At present we know of no incombustible substitute for wood which could be used in the finish of a building, at no greater expense for first cost and for maintenance, and with equal satisfaction from all points of view to the user.

There is no need to tell Mr. Atkinson that the primary purpose in erecting a building is not to see how perfectly proof against fire it can be made. Buildings are erected to give satisfaction to those who are to occupy them, and to make money for their owners. Architects, builders and insurance men have to take the industry as it is.

The public demands—and educated taste sustains its demands—that buildings of first-class construction be finished in natural woods. It will surely reject any of the substitutes for wood, or the "wood encased in metal" which Mr. Atkinson proposes. His suggestion of such substitutes, therefore, amounts to nothing practically as an argument against "fireproof wood—so-called." The question is whether the additional safeguard which the fireproofing gives to the wood finish of a building is worth the additional cost, and this question is one fairly open to discussion and to the light of further facts.

Prof. Norton, indeed, admits that the use of fireproofed wood constitutes an additional safeguard against the spread of fire; but he thinks it so slight a safeguard that its use may well be dispensed with. As seen above, however, he attaches little value to the reduced inflammability in the treated wood, and we can but feel that in this respect his position is a mistaken one.

We ourselves have always held that the legislation by which the use of this treated wood was made compulsory in certain classes of buildings in New York city was a mistake. We strongly suspect that if the secrets of all hearts were laid bare this legislation would be found to have originated with the manufacturers of "fireproof wood—so-called." It is doubtful whether the risk of the spread of flame in a first-class fireproof building and the extent to which the work of the firemen would be aided by the presence of treated wood in the finish of the building has yet been sufficiently well established to justify legislation to make the use of such wood compulsory.

Nevertheless, we are far from agreeing with Messrs. Atkinson and Norton that such wood is of little or no value. Enough is now known of its resistance to ignition and its slight inflammability to justify architects and engineers in adopting it for places where these qualities will be of special service. It is true, as Prof. Norton points out, that no accepted test to determine the thoroughness of the treatment at present exists. This, it is to be hoped, may be remedied, however, through the work now in progress at Columbia University for the New York Building Department. If this is done the use of "slow-burning" wood—to give it its proper name—will be on a much more satisfactory basis.

LETTERS TO THE EDITOR.

A Concrete-Steel Retaining Wall.

Sir: In your issue of March 27 and again on Aug. 7, 1902, you describe and illustrate a "new design of concrete-steel retaining wall" patented by Mr. Frank A. Bone, presumably in 1901. The writer conceived this idea some ten years ago, and finally in 1899 described and illustrated it in a lecture delivered before the Association of Civil Engineers of Cornell University. The paper was published in the "Journal of the Association of Engineering Societies," Vol. XXIV., No. 1.

The question naturally suggests itself whether or not a patent could be granted for something which was already public property; and if so, would not the retaining wall of this pattern be an infringement on some of the existing patents of concrete-steel construction?

Yours truly, David Molitor.

Fond du Lac, Wis., Aug. 27, 1902.

(A patent is like a deed to a piece of land. The area which it covers is defined in the document itself, and it covers nothing else. The claims of a patent correspond to the description by metes and bounds in a deed. Evidently a retaining wall like that which our correspondent described in 1899 could be built without infringement on Mr. Bone's patent—unless Mr. Bone could prove invention at an earlier date. At the same time, there may be in Mr. Bone's patent claims to certain details of construction that are perfectly valid.—Ed.)

Cost of Laying Brick Pavements.

Sir: Concerning the communication of Mr. Gillette (Eng. News, Aug. 21), permit me to say that I used the term "incontestable evidence" to make the statement particularly strong. I have seen 10,000 to 12,000 brick blocks laid per man per day for several days at a time under several different contractors, I myself keeping the tally and checking with the official inspector; and disinterested friends have given me similar reports from other cities where they have kept the tally; and further, several reliable contractors, with every appearance of sincerity, have confirmed the above results. During the past two weeks four men in this city have set an average of more than 11,000 (the exact number is not at hand at this writing) brick blocks in 10 hrs., including making their own closures and setting the blocks diagonally at street intersections. The number set in a unit of time will depend upon the manner in which the bricks are delivered to the setters; if the bricks are delivered on a board or piled on the edge of those already set, a man can set considerably more than if the bricks are delivered by being tipped from a wheelbarrow. In the examples cited above, the brick blocks were tipped from a wheelbarrow upon the blocks already set. Measured by the area covered, 10,000 and 12,000 blocks are equivalent, respectively, to 13,000 and 16,000 small bricks—the size Mr. Gillette employed in his original communication.

Mr. Gillette misuses the cost of laying brick in Minneapolis, in checking his estimates. The cost of laying brick at Minneapolis was 3.2 cts. per sq. yd.; but we do not know how much of that cost was for delivering the brick to the setter, and hence we cannot deduce therefrom the number laid per hour.

The writer believes that Mr. Gillette makes a mistake when he reasons that a thin sand cushion gives a firmer and smoother pavement than a thicker one. If the pavement is thoroughly rolled, a 2-in. sand cushion will make a firmer and smoother pavement than a thinner one, since the thicker layer seems to allow the sand to adjust itself better and to allow the brick to be bedded better, at least the brick are firmer and the surface smoother. As evidence that the sand does flow during the rolling, it may be mentioned that it is common experience that with a 2-in. cushion the sand will be forced up between the bricks from ¼ to ½-in. To accomplish this result, the brick should be rolled several times; at least three or four.

Yours truly, Ira O. Baker.

Champaign, Ill., Aug. 23, 1902.

Reheating Steam Between the Cylinders of Compound Engines.

Sir: Referring to the paper on an "Engine Test to Determine the Effect of Reheating between the Cylinders on a Compound Engine," in your issue of Aug. 21, the condition of the steam during the test was not recorded; that is, whether it was superheated or supersaturated. This is a very important factor and the condition of the steam probably determines whether there is profit or loss in the use of the reheater.

By referring to p. 320, Vol. XIX., "Transactions of the American Society of Mechanical Engineers," will be found the results of tests published by the writer on a tandem compound engine, in which the rate of water consumption was 19.34 lbs. per I. HP. per hour without reheating. This rate was increased to 20.45 lbs. when steam at boiler pressure was used in the reheater. These results were obtained from prolonged experiments, under conditions favorable to accuracy; all as described in the paper above referred to. At the time the experiments were made, no satisfactory method was at hand for determining the quality of the steam, but it was known to be far from perfect. Subsequently, it was found that the steam carried about 7% moisture. This large amount of suspended water, passing through the reheater, was naturally a wasteful method of heating, as all this suspended water, when caught at the point of discharge, was weighed and charged up as steam.

At a later period than that above referred to, similar tests were made, on a much larger engine, but under similar conditions to those of the first experiment, excepting that the steam pipes were better protected and the water carried by the steam fell a little below 2%. These were Allis engines, cross compound type, cylinders 20 and 40 ins. × 48 ins. stroke, driving a 500-K-W. generator at 92 revs. per min. The night load was considerably greater than the day load. With the night load averaging 560 HP., the water per I. HP. hour was 13.32 lbs. with reheater and 13.16 without reheater. For the day load, which averaged 440 HP., the water rate was 13.37 lbs. with reheater, and 13.79 without the reheater.

The consumption of steam with and without the reheater with this engine, was nearly equal. Accidental circumstances might cause it to appear that the consumption of steam at the higher horse-power was a little higher with the reheater than without, whereas contrary results were obtained with the lower output of power. It is quite probable that if the steam carried no superfluous moisture—or better still—if superheated, that a distinct gain would be shown by the use of the reheater.

Yours truly, James Christie.

Pencoyd, Pa., Aug. 25, 1902.

The Law of Boundary Surveys—Chains and Links a Standard for Government Land Measure.

Sir: I notice in Engineering News of Aug. 28 the article by Mr. Kern on the law of boundary surveys.

Speaking of the location of the center of a section, he says the pamphlet issued by the general land office "suggests that it be placed at the intersection of lines run from the opposite corners." He then gives a very different method as the correct one.

The method by intersection of straight lines between the opposite corresponding quarter-section corners is not the suggestion of the land office, but the mandate of the United States statutes creating the U. S. system of land surveys (act of Feb. 11, 1805), and Mr. Kern's method, while well enough at common law, is not in harmony with the statute.

In regard to standards of measurement, so far as surveys under the United States land system are concerned, that is also settled by the same statute. It says that "the corners marked in the surveys returned by the surveyor-general shall be established as the proper corners, etc.," and that the length of the lines as returned "shall be held and considered as the true length thereof." This establishes a standard of length actually laid down and marked in the ground for every line run by the deputy surveyor and returned by the surveyor-general. When the field notes say it is 40 chains from a section corner to a quarter post, it is 40 chains, and when they say it is 39.25 chains, that is what it legally is, for all purposes of locating boundaries under the United States land system, any other so-called standard to the contrary notwithstanding.

In this connection I notice that in a recent discussion of the metric system by the Western Society of Engineers, one of the speakers alludes to the rod and chain as "having been weeded out as being superfluous, while the foot as a unit was extended in its usefulness to cover land surveys." It is doubtless true that civil engineers whose principal work and thought is in units of feet prefer to retain that unit when on rare occasions they have something to do with land surveying. It is also true that in locations where land is so valuable as to make it of advantage to sell and reckon it by the square foot rather than the acre, the foot is used as the unit of measure.

All this, however, covers but an extremely small portion of the United States. All the public lands of the United States, including about 80% of its territory, have been or are being surveyed on the United States land system. In these surveys distances must be measured and returned in miles, chains and links. The use of the engineer's chain divided into feet is absolutely prohibited. With the use of the chain as a unit we have all the advantages of a decimal system. The surveyor who in making surveys and subdivisions of sections under the United States land system should abandon the chain in favor of the foot as a unit might well be compared with the chemist who should abandon the metric system and return to the old systems of weights and measures. It is a decided step backward from the new to the old.

F. Hodgman.

Climax, Mich., Aug. 30, 1902.

Practice in Subdividing Lands Below an Original Meander Line.

Sir: I desire to get the experience and method usually employed, by surveyors generally, in reference to the proper method of subdividing land around a lake, where the water has receded from the original meander line, as established by the government surveyors some 60 years ago, and will ask you to kindly insert this as an inquiry in the columns of the "News." The lake I have reference to is a deep one, probably 30 or 40 ft., in places and is about three miles long and two miles wide. The recession amounts probably to a strip from two to six rods wide on nearly all sides of the lake and the present, as well as the original outline, is very irregular. B. H. S.

Manistee, Mich., Aug. 25, 1902.

(We quote in reply to the above the following from Johnson's "Theory and Practice of Surveying," pp. 232, 233.—Ed.)

WATER BOUNDARIES AND MEANDERED LINES.—1. Meandered lines on the United States land surveys were run for the purpose of outlining lakes and rivers, and are is no sense boundary lines. They served for computing the areas of the fractional quarter-sections which were used in the first sales by the government, but the real boundary is the center of the stream if not navigable, and the line of ordinary high water or line of vegetation, if navigable. In the case of lakes and ponds described as boundary lines the ownership is to the water's edge.

2. In extending side boundaries beyond the meandered lines to the river bank or lake shore, such extensions be-

yond the meandered lines should run at right angles to the shore. This rule also applies to city lots and to all lands fronting on bodies of water. An exception to the rule is the following:

3. When the waters of a lake recede from drainage or any other cause, or when a river or creek shifts its course, the accretion or "made land" belongs to the abutting property and should be divided in proportion to the original lengths of water frontage. If the land thus acquired is the valuable consideration, then the original side boundaries are to be extended so as to divide the new *area* among the abutting tracts in proportion to their original frontages; but if the length of the new frontage is the desirable thing, then the new *line of frontage* is to be saved to the original tracts possessing such privileges, in due proportion. In either case, the extension of the side boundaries will usually involve angles at the meandered or original water line and these extensions will, in general, run nearly at right angles to the new shore line.

4. A "bank" of a stream is the continuous line where vegetation ceases. A "shore" is the exposed ground below the bank line.

5. The rights of ownership extend to the center lines of non-navigable streams and lakes, but only riparian rights obtain in the beds of navigable streams or lakes.

6. Where land is specifically bounded by "the bank," or "along the bank" of a stream or lake, these words will exclude all ownership of the bed of such stream or lake. Whether they would exclude riparian rights also would depend on the circumstances of the case and on the understanding of the parties.

In computing the area of a survey the terms "from," "to," or "with" the bank of a stream mean to low-water mark.

7. In the case of meandered river banks or lake fronts on the United States land surveys, the computed areas included only up to the meandered line, all outside of that belong to the tract by a natural right. Hence in any subsequent sales of the tract the area should only be computed to the meandered line unless the conveyance specifically calls for an extension "to" or "along" the shore or bank, in which case the area would be computed to low-water mark, as above stated.

8. Similarly, when an area is to be laid off from a tract bounded in part by a meandered line, this area should be computed only up to the meandered line unless otherwise specifically stated.

Notes and Queries.

The high-speed locomotives referred to in a note on p. 131 of our issue of Aug. 21, have been ordered by the German State Railway and not the Russian, as stated in the note.

We have been requested to state that, owing to the exhaustion of the author's copies, those desiring the pamphlet by Prof. L. P. Kinnicutt, on "The Present Status of Sewage Disposal in England," are referred to the June number of the "Journal of the Association of Engineering Societies," 254 South Fourth St., Philadelphia; and that those wishing the paper by Professor Kinnicutt and H. P. Eddy on the "Action of the Septic Tank on Acid Iron Sewage," should apply to Mr. R. A. Cairns, Secretary State Sewerage Commission, Waterbury, Conn.

T. C. B., Washington, D. C., wishes to know the amount of water power now used in the United States; also the longest distances to which it is electrically transmitted, and the prices at which it is sold.

We know of no accurate, up-to-date statistics of the use of water power. Possibly the Census Bureau may have some in preparation. The longest transmission in the United States or in the world is that of the Standard Electric Co. and Bay Counties Power Co., in California, 220 miles. (See Eng. News, vol. July-Dec. 1901, pp. 230, 236, 428.) The prices at which power is sold vary probably from $10 to $100 per HP. per annum, with some exceptional cases above and below these extremes.

ENGINEERING AT THE LOUISIANA PURCHASE EXposition will be represented in Groups 25, 26 and 27 of the Department of Liberal Arts, with Mr. J. A. Ockerson, M. Am. Soc. C. E., as Chief of the Department. Group 25 covers civil and military engineering, and includes materials of construction, methods and apparatus for testing materials, tools, equipment or plant used in building operations, etc. Group 26 covers models, plans and designs for public work of all description; and Group 27 is devoted to architectural engineering, with models and plans of public, commercial and domestic buildings of modern design. Mr. Ockerson is very desirous of making this exhibit worthy of the energy and skill of American engineers and architects; and he particularly asks that models be sent, as being the most effective exhibits where full-sized examples are too cumbersome. Next in importance are photographs showing the various stages of progress up to completed work. The Department of Liberal Arts will occupy an entire building covering an area of about 400,000 sq. ft., to be built at an estimated cost of $500,000.

THE TEHUANTEPEC RAILWAY PLAN, as embodied in the recent contract between the Mexican government and S. Pearson & Son, of London, is given as follows by U. S. Consul W. W. Canada, of Vera Cruz: The contract calls for the improvement, completion and operation of the Tehuantepec National Railway and the terminal ports of Salina Cruz and Coatzacoalcos, and is substituted for the contract of 1890. The government and the firm practically enter into a partnership, with a corporate capital of $5,000,000 Mexican, for a period of 51 years, from July 1, 1902. If there is a loss of $4,000,000 Mexican the contractors may regard the contract rescinded; and the government can cancel if the contractors fail to contribute their share. The company must keep the railway and ports in good condition, make at least two trips per week with mixed trains, and carry passengers across in not more than 14 hours. The fares and freight rates are fixed in the contract. The company is to establish a maritime service in the Pacific, and to begin with a steamer of not less than 2,000 tons or 12 knots speed; other vessels are to be put on as needed.

THE JULY EXPORT OF MANUFACTURES, says the U. S. Treasury Bureau of Statistics, was greater than that of July last year, or as $33,598,848 is to $31,852,440. The total imports of manufacturers' materials for the seven months ending with July amount to $252,305,050, as against $221,537,767 for the same months of last year. For the same period the total export of manufactures is $245,756,052 against $236,003,429 for the same months in 1901.

AUGUSTUS TORREY.

Mr. Augustus Torrey, Chief Engineer of the Michigan Central R. R., died at Detroit, Mich., on Aug. 20 from injuries received during an inspection trip on the previous day, as noted last week. Mr. Torrey was a comparatively young

Augustus Torrey.

man, having been born at Beverly, Mass., on Nov. 21, 1850. He entered the University of Vermont, graduating in 1872, and commenced his professional career on the Burlington & Lamoille R. R. (now a part of the Central Vermont R. R. system) of which he was Division Engineer from 1874 to 1876. He then turned to hydraulic engineering, and was engaged in this sort of work at Burlington, Vt., and some towns in Massachusetts. He was Superintendent of Water-Works at Burlington, Vt., from 1870 to 1880, when he went to the Michigan Central R. R. with the late Edward H. Phelps, his first work being as Assistant Engineer in charge of the location and construction of the extension of the old Jackson, Lansing & Saginaw R. R. from Gaylord to Mackinaw, Mich. After this work was completed he served as Assistant Engineer under Mr. Phelps until the latter's death in 1884, and when Mr. J. D. Hawks was appointed Chief Engineer of the Michigan Central R. R. Mr. Torrey became his Principal Assistant Engineer. He served in this capacity until the resignation of Mr. Hawks in 1892, when he was appointed Chief Engineer.

The injuries which resulted in his death were caused on Aug. 19 by jumping from a gasoline inspection car while going over the new second track work between Jackson and Marshall. The car was overtaken by a fast freight train, and as there was no time to remove the car Mr. Torrey and his two companions jumped. His companions were unhurt, but Mr. Torrey fell upon a pile of rails and sustained the severe injuries from which he died in a hospital at Detroit on the following day.

He was of a progressive character in his professional work, carrying out many experiments and introducing a number of new ideas. He took particular interest in the question of track improvement, experimented with continuous rails in lengths of 100 to 800 ft., designed a ballast-loading machine, which is now put on the market by a railway supply firm, and devised a form of rail joint (Eng. News, Nov. 30, 1899) which has been found very successful. His book on "Switch Layouts and Curve Easements" is well known and widely used. He was one of the leading spirits in organizing the Railway Engineering and Maintenance of Way Association a few years ago, and was Chairman of the Preliminary Organization which conducted affairs previous to the official establishment of the association, after which he was elected one of the Directors. He became a member of the Western Society of Engineers in 1896. The accompanying portrait is from an excellent photograph of recent date. Mr. Torrey was a man of genial character, and always willing to give information and assistance. He was of very high standing professionally, and was of a very lovable disposition in his family and social associations. He was twice married, and leaves a widow, a son and four daughters.

THE ADJUSTMENT OF MACADAM ROAD DESIGN TO VARIOUS SUBGRADE SOILS.*

The methods employed by the commission in building state roads have been thoroughly described in previous reports, and will not be repeated at this time.

The main difficulty the commission has to contend with is to apply the method which will give perfectly safe and at the same time economical results when the road to be built passes over a subgrade of doubtful soil. Such roads can be built to bear up the heaviest load that may be expected to pass over them during all conditions of weather; but when the drainage and foundation which may seem to be necessary to produce good results are effected, the cost is great, and unless these precautions are required, the heavy cost is unnecessary.

It is a well-known fact to road builders that, with reasonably good grades, the surface of the road is much easier to maintain on grades than on the low ground between two hills or on any flat grade. This is particularly true of gravel roads.

The soils found in the subgrades may be divided into three general classes: First, sand or gravel; second, clay; and third, sandy loam.

SAND OR GRAVEL.—The thickness of the roadway surfacing over sand and gravel is determined by weight and volume of traffic alone. On roads of light traffic this thickness is 4 ins., which is increased to 6 ins. on heavy traffic roads. The increased thickness is used more particularly to reduce the cost of maintenance, as by its use the road will wear a much longer period of time before it will require picking up and resurfacing.

The main feature of building thin macadam roads over sand is to thoroughly compact the stone by rolling before opening them to traffic, as by so doing subsequent movement of the fragments of broken stone is prevented, and ruts will not develop.

CLAY.—Clay as found in subgrades is a variable substance. It may be a pure blue clay, or it may be mixed with sand in different proportions. The pure blue clay subgrade requires heroic treatment, if positive stable results are expected. The ground water must be removed as far as possible, to insure a reasonably dry foundation. This may be done by one or two side drains, the number depending upon the general slope of the adjacent ground, or by a center drain.

It is customary to place one drain on the up-hill side, and one on each side in a cut or on a level grade. It is not at all times an easy problem to determine whether side or center drains should be put in, and no general rule can be laid down that will cover this part of the work. A special study must be made of the subgrade and of the stone or gravel supply, and comparative estimates based upon these studies will make an intelligent conclusion possible. If a good quality of gravel can be found within a reasonable distance from the road which is being built, it is economical to spread it on the roadway to a depth of from 2 to 6 ins. over the clay subgrade, and on this gravel to spread the broken stone. The gravel thus placed serves a double purpose—it improves the drainage and reduces the depth of the broken stone surfacing. Gravel placed in this manner should be used only when it can be placed on the road for a price that is less than would be paid for broken stone; at the same cost per cubic yard, broken stone is preferable.

Clay that is mixed with more or less sand has to be

*From the report of the Massachusetts Highway Commission for the year 1901. W. E. McClintock, Harold Parker and John H. Manning, Commissioners.

studied very carefully. If the percentage of sand is large and the grains of sand coarse, the drains on grades may possibly be omitted and probably need be put over only fairly level places, and the thickness of the broken stone and of the gravel may be lessened. If, on the other hand, the sand be fine-grained and in smaller proportion, a great deal of judgment is needed to know just how it should be treated.

The standard thickness of covering should be used on

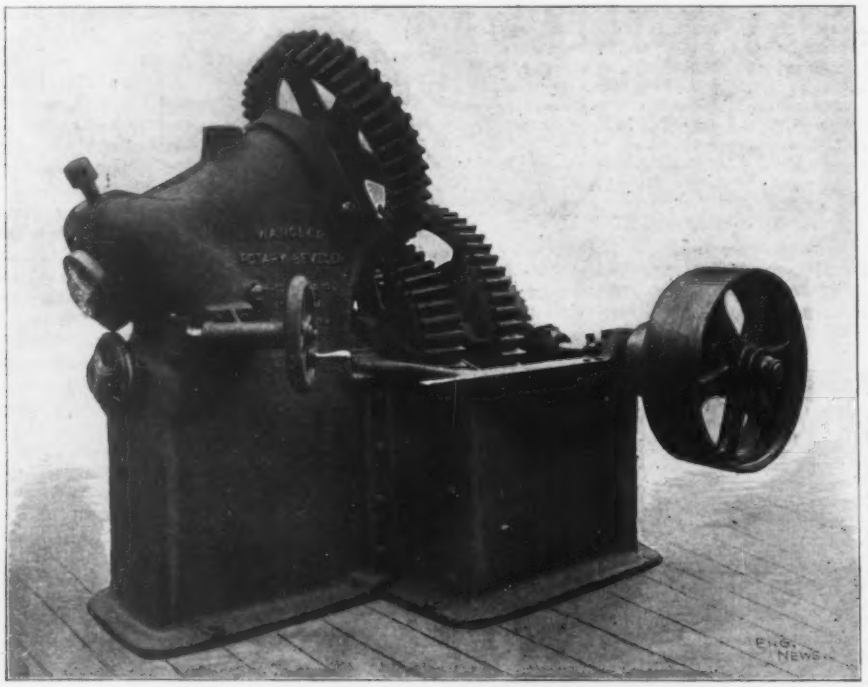


FIG. 1. ROTARY BEVELING SHEAR FOR BEVELING PLATES.
Chas. J. Wangler, St. Louis, Mo., Inventor. Scully Steel & Iron Co., Chicago, Ill., Manufacturers.

level stretches, with a possible reduction in depth on grades. If any weakness develops later on, the thickness of covering may be obtained by spreading on more stone and rolling it.

On the same principle, the drains may be omitted at the time of building, putting them where needed only at any subsequent time, if the roadway shows indications of rutting.

SANDY LOAM.—A subgrade of sandy loam is the most difficult to know how to treat. Generally speaking, if 30% or more of the material will pass through a No. 100 screen, the introduction of a drain does no particular good, the capillarity of the soil being so great that it will not give out the ground water. Under frost action the bearing-up properties are very poor, and the thickness of the covering will have to be increased until the weight is distributed over an area large enough to reduce the pressure to a safe limit.

When this kind of soil is met with, it is exceedingly variable in quality, and unless tests are made at very short intervals its character cannot be determined. It is therefore well to place the broken stone, or stone and good gravel, on the road to a depth of 12 or 14 ins. when the sandy loam is known to be poor, and to reduce this thickness to 6 ins. when it is of doubtful quality. If in the use of the road weak spots develop, these spots can be strengthened by placing more stone over that already there, and thus increase the thickness. By this method no greater outlay is incurred than is actually necessary, as determined by experience.

A NEW ROTARY BEVELING MACHINE.

A powerful but simple rotary shear or beveling machine has recently been put upon the market by the Scully Steel & Iron Co., of Halsted and Fulton Sts., Chicago, Ill. The purpose of the inventor, Mr. Charles J. Wangler, of St. Louis, Mo., is to provide a simple, durable and efficient construction, which would avoid the usual lateral strain upon the carrying shafts of the cutters, with the accompanying liability in these shafts to spring and break at a point near the cutters. The design also permits a convenient adjustment to shearing circular work of various diameters, and it reduces the wear of the shaft-bearings.

The illustration sufficiently shows the simplicity and strength of the design. The shafts carrying the cutter-disks are arranged obliquely to each other, with both shafts so geared that their movement is positive. The upper cutter-disk has a cylindrical periphery, while the lower cutter has a similar periphery beveled at its rear edge, the intersection of this bevel with the upper cutter constituting the cutting edge, with the lower cutter at the same time forming a support for the material to be beveled.

The upper and oblique cutter-shaft is mounted in a tubular housing pivoted at its rear end in the main housing; concealed inside the main housing is a weighted lever, with the front end of this lever terminating in a friction roller bearing upon a short inclined track or lug on the bottom part

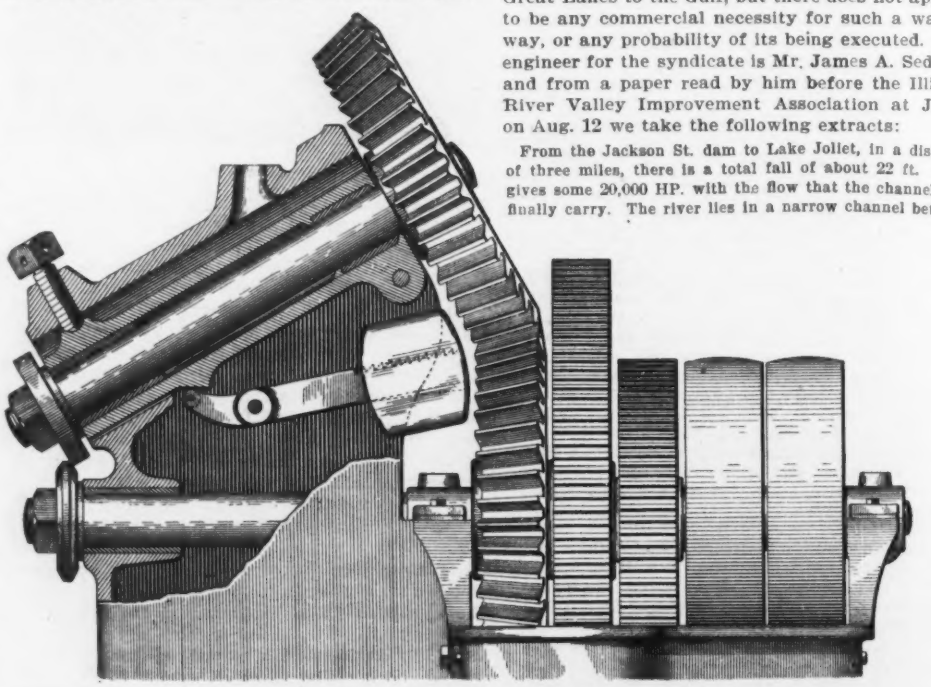


FIG. 2. LONGITUDINAL SECTION OF ROTARY BEVELING SHEAR.

of the tubular housing mentioned. By means of the upward thrust of this weighted lever and the adjusting screw, shown on top of the forward part of the main housing, the oblique cutter-shaft can be adjusted to the cut desired. Both cutting disks are reversible, so that in case of injury to one side of the blade, the other side can be used at once. This shear can be operated either by belt power, through a friction pulley, or by an electric motor, and the machine shown will bevel [illegible] plate.

WATER POWER PROJECTS AT JOLIET, ILL.

The rival water power projects at Joliet, which are projected by the Sanitary District of Chicago and by the Gaylord Syndicate are now before the courts for a decision as to their respective rights, as already noted in our columns; and the general situation is shown by the accompanying map. At the extreme right is the State dam at Jackson St., Joliet. On the south side of Desplaines River the Sanitary District has already built an embankment extending to the mouth of Hickory Creek. An approximate location for the District dam and power house is shown above the mouth of the creek, but no definite statement as to the exact location or the head to be secured can be made until the courts have defined the District's rights and its power to erect the works at the point selected. Below the dam a tail-race channel to Lake Joliet would be excavated in the bed of the river. These works have been planned by Mr. Isham Randolph, Chief Engineer of the Sanitary District.

The Gaylord Syndicate propose to build a dam much farther down the river, obtaining a head of about 21.5 ft (from the tail-race level of the present Joliet dam). About 10,000 electrical horsepower would be developed, or 15,000 HP. in about five years, when the Chicago River improvements are completed. To form the reservoir, the embankment or levee on the south side of the river would have to be extended to the site of the dam, and the power house would form the end section of this embankment, independent of the main dam. To avoid backing up the water in Hickory Creek, which would cause a flooding of part of the city, the plans provide for closing the present mouth and diverting the creek into a new channel outside of and parallel with the river embankment, this channel discharging into Lake Joliet below the dam. This arrangement is shown on the plan. The river embankment would be of earth, with the slopes protected by rock-fill toe walls. Considerable advantages are claimed for this scheme in connection with a future deep waterway from the Great Lakes to the Gulf, but there does not appear to be any commercial necessity for such a waterway, or any probability of its being executed. The engineer for the syndicate is Mr. James A. Seddon, and from a paper read by him before the Illinois River Valley Improvement Association at Joliet on Aug. 12 we take the following extracts:

From the Jackson St. dam to Lake Joliet, in a distance of three miles, there is a total fall of about 22 ft. This gives some 20,000 HP. with the flow that the channel will finally carry. The river lies in a narrow channel between the Illinois & Michigan Canal embankment on one side and the Sanitary District levee on the other, from the State dam down to the mouth of Hickory Creek. Here it spreads out in a wide section with low bottom lands on each side, and runs down through a number of channels with islands between them, until it finally drops into the Lake Joliet level about ½ mile below the Brandon Road bridge. The steepest slope in this river is found in the broken channels from Brandon bridge up to the mouth of

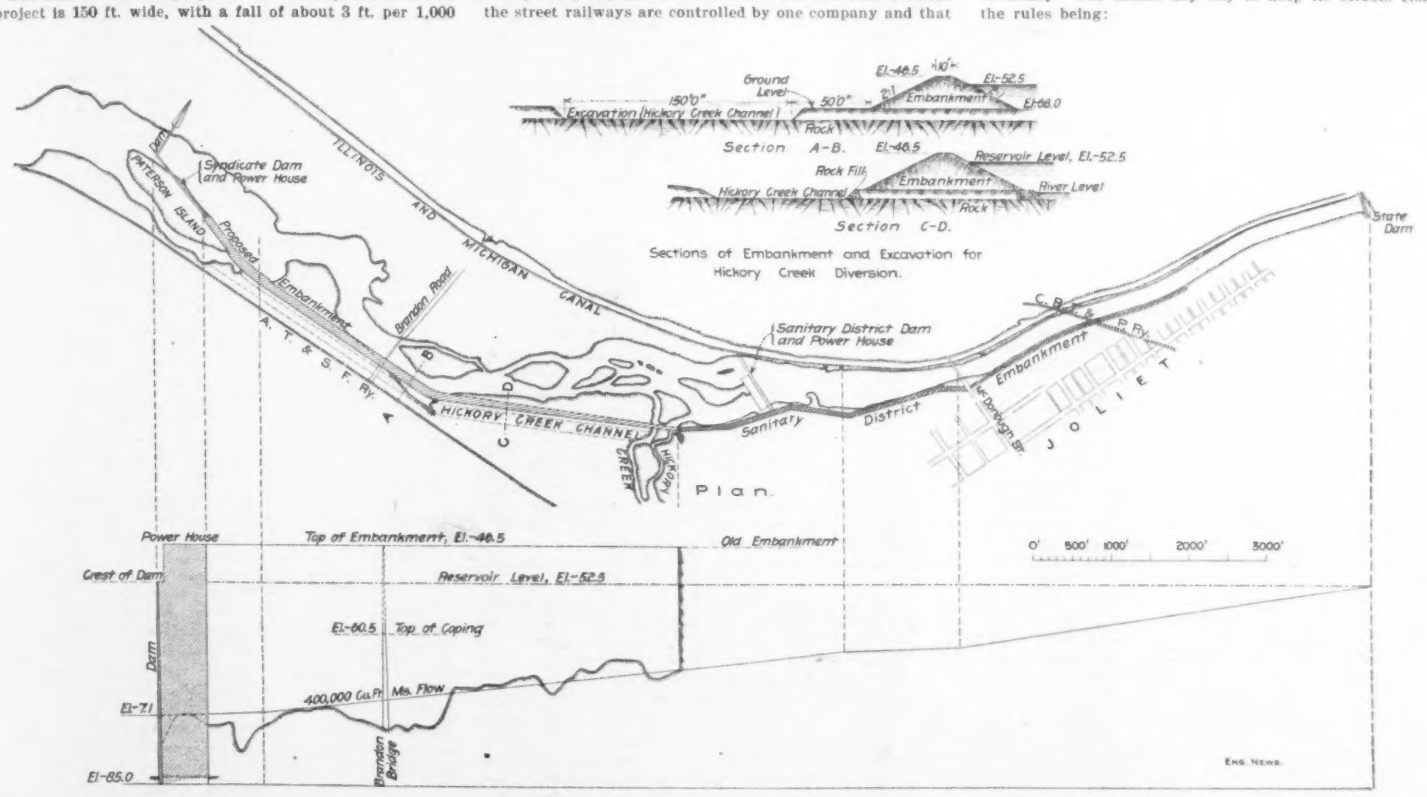
Hickory Creek; and the line of South St. (or the southern boundary of Joliet) about divides the total fall of 22 ft. in this division of the river. The drainage and the grades of all the lower part of the city of Joliet are at a level, which does not allow the waters of Hickory Creek to be backed up to any considerable degree.

One way of treating this problem is to build the dam above the mouth of Hickory Creek, which, of course, can not then back the water up in it. But in order to get the power in the lower half of the fall in that case a deep channel or tail-race must be cut from the dam down to Lake Joliet. The alternative project is to build the dam down at the head of Lake Joliet, with all of this 22 ft. of fall above it, and avoid backing the water up in Hickory Creek by bringing it down to the lake outside of the reservoir. This is done by building an embankment from the dam up the bottom lands on the Hickory Creek side of the valley, shutting the creek out from the river above and cutting a channel for it down to Lake Joliet back of this embankment.

The dam above Hickory Creek, with a deep cut to Lake Joliet, I take it, is now the project of the Sanitary District. The dam down in the head of Lake Joliet, with an embankment up the Hickory Creek bottom and channel for the creek back of it is the project of our company.

The engineering works in these alternative projects are a dam and power house in each case, with less height for the upper dam and more rock excavation in its power house. But the mile of tail-race for the drainage canal flow that will bring the Lake Joliet level up to this dam is a second drainage channel cut through rock, and the excavation from it would more than build the embankment on the Hickory Creek side called for in the other project. In the case of the lower dam, the excavation required is only a channel down to Lake Joliet cut through the surface soil on a grade that will carry off the flow of Hickory Creek, and any additional earth that may be needed to build the embankment may be dredged out of the head of Lake Joliet, and put on it for 15 cts. per cu. yd., against the costly rock excavation in the first project.

The channel that is proposed for Hickory Creek in our project is 150 ft. wide, with a fall of about 3 ft. per 1,000 ft. This is ¾ of the width and 1½ times the slope of the channel cut by the Sanitary District below the Jackson St. dam for the combined flow of the drainage canal and the flood waters of the Desplaines River. This channel at its head will draw the natural flood level of the creek down at least 3 ft.



MAP SHOWING APPROXIMATE LOCATION OF RIVAL WATER POWER PROJECTS AT JOLIET, ILL.

ANNUAL MEETING OF THE LEAGUE OF AMERICAN MUNICIPALITIES.

The sixth annual convention of this organization was held at Grand Rapids, Mich., Aug. 27, 28 and 29. Mr. John MacVicar, Secretary, reported that during the year nine new cities had joined the league and two had been reinstated. Withdrawals had been but few. The treasurer reported receipts of $2,935 and disbursements of $2,727. Baltimore was chosen as the place of the next meeting. Mr. J. Adger Smythe, Mayor of Charleston, S. C., was elected as president, and Messrs. John MeVicar, of Des Moines, Ia., and Thos. P. Taylor, of Bridgeport, Conn., were re-elected secretary and treasurer, respectively.

The constitution was amended to provide for three grades of membership, as follows:

(1) Active members, who shall include all those holding municipal offices and representing cities who have paid their annual dues, and who shall be entitled to vote on all questions; (2) Honorary members, to include all those who have held municipal office and have been members of the league, who shall have the privilege of the floor, but not be entitled to vote; (3) Associate members, who shall include the editors of municipal journals, individuals and firms engaged in making municipal necessities, without power to vote, but who shall pay an annual fee of $10, for which they shall be entitled to exhibit their machinery on the floor or adjacent to the convention.

MUNICIPAL OWNERSHIP AND HOME RULE.

This was the topic of the presidential address, delivered by Mr. Chas. S. Ashley, Mayor of New Bedford, Mass. Competition between public service corporations, he declared, results in consolidations and eventually the consumers must pay all the bills. Attempts at public regulation of franchise companies are farcical. Notwithstanding these assertions, and equally emphatic ones regarding the lack of municipal home rule in Massachusetts, Mr. Ashley cited instances which seemed to show that New Bedford has coped unusually well with several franchise corporations, having secured material reductions in the cost of street lighting; three-cent street railway fares for workingmen, together with a gross sum for widening streets and annual contributions to the city treasury, and the introduction of telephone service by the Automatic Telephone Co., followed by reduced rates on the part of the Bell Co.

TAXATION AND TRANSPORTATION IN THEIR RELATION TO MUNICIPAL GOVERNMENT.

Mr. J. M. Head, Mayor of Nashville, Tenn., dwelt at some length upon the surrender of the power of taxation, by the federal, state and municipal governments alike, to private individuals and corporations. He asserted that in nearly every city of 50,000 inhabitants in the United States the street railways are controlled by one company and that company controls the city government. Worse yet, he maintained that of late these consolidations have been coming under the control of one man, responsible neither to the government nor the public. As a remedy, Mr. Head advocated home rule for cities and the resumption of taxation by them; the latter, it may be inferred, to be effected largely through municipal ownership.

CANADIAN MUNICIPAL CONDITIONS.

Mr. W. D. Lighthall, Mayor of Westmount, Que., pointed out the similarities between municipal conditions in the United States and Canada, with the exception of the greater freedom from party politics, and longer tenure of office in Canada. He strongly favored municipal ownership and outlined the scope of the Union of Canadian Municipalities, organized a year or so ago, and which is to hold a meeting at Montreal on Sept. 15. The chief object of the Canadian organization seems to be to secure legislation in the interests of the municipalities, and it is felt that a good beginning has already been made.

THE MUNICIPAL CONTRACT SYSTEM.

Arguments for doing municipal work by contract, a description of the work of the Board of Awards in Baltimore, and instances of reduced contract prices in that city, were presented by Mr. Thos. G. Hayes, Mayor of Baltimore. The Baltimore plan* vests all contract awards in a board composed of the mayor, comptroller, register, solicitor, and president of the second branch of the city council. The department for which the work is to be done prepares the specifications and submits them to the board for amendment and approval. Mr. Hayes declared that the plan is death to the spoils system and gives all the advantages due to having employees working for a private employer, instead of the henchman of a political boss. The instances of reduced prices under the board include the following: $99.92 instead of $127.75 each for electric lights; $14.15 against $23.84 for gas lamps; $148,000 per annum for garbage collection and disposal, against $177,800. The latter price was the cost for the work done by the city, and with makeshift disposal, while the contractor must construct and operate a disposal plant.

STREET CLEANING IN DETROIT.

The way in which Detroit has achieved a reputation for its street cleaning work was described in a paper by Mr. D. W. H. Moreland, Commissioner of Public Works. The central portion of the city is cleaned by about one hundred "white wings," with brooms, shovels and push carts. The work in the rest of the city is done by ward gangs. During the year ending June 30, 1902, a total of $158,000 covered all expenses, including new machine sweepers and hand tools, for cleaning 910 miles of streets and alleys, divided as follows: 286 miles of paved streets and 20 miles of paved alleys; 276 miles of unpaved streets and 328 miles of unpaved alleys; or 306 miles of paved and 604 miles of unpaved streets and alleys. Litter barrels and "Don't Spit" signs, together with the co-operation of merchants, have played an important part in the work of keeping the streets clean. Five "cast iron rules" and a "fair amount of money" will enable any city to keep its streets clean, the rules being:

(1) Study the problem of street cleaning. (2) Buy only the best machinery and tools. (3) Employ only good teams and able-bodied men. (4) Eliminate politics. (5) Keep "humping."

During the past winter snow removal was greatly facilitated by dumping snow, slush, and even cakes of ice through large manholes into a 9-ft. sewer 25 to 37 ft. below the surface of the street, there to be melted or carried away to the river.

STREET PAVING IN BALTIMORE.

A paper on this subject was read by Mr. Benj. Fendall, City Engineer of Baltimore. The first pavements were of cobblestone, put down about the time of the American

*See editorial discussion of this plan in our issue of Nov. 24, 1898, and also a letter from a Baltimore correspondent, in our issue of Dec. 8, 1898.

Revolution. A large amount of this material is still in use. Granite blocks on sand cost about $2 per sq. yd., and are relaid for 35 cts. Experience has not yet shown whether fire-clay or shale-brick pavements are preferable in Baltimore. About ten miles of asphalt block has proven satisfactory, being less slippery and less expensive to maintain than sheet asphalt, while at the same time having all the good qualities of that material. Recent improvements in manufacturing asphalt blocks will probably result in a more durable and less expensive product. A small area of creo-resinate wood block pavement was laid last year and a little more is being put down this year. The Warren bituminous macadam has not been tried, but is under favorable consideration.

By far the most notable part of Mr. Fendall's paper was a suggestion that the league take steps to formulate a standard price, or prices, for sheet asphalt pavement, based on the proper unit values, and then ask the municipalities of the whole country to consider the advisability of fixing the maximum price for such pavement in each city. The author did not know as the plan was practicable, but was certain that a check on the asphalt monopoly is needed when Washington is getting asphalt for $1.56, Baltimore pays 50% more, and other cities 100% higher. At Baltimore the cost of sheet asphalt has ranged from $1.52 to $3.50 per sq. yd., the lowest figure being paid to the Alcatraz Co. before it was absorbed by the trust.

GAS LEAKAGE IN CITIES.

This paper was by Mr. Jas. C. Bayles, an engineer who has written a number of articles and papers, of late, on the relation of gas leakage to health, fire risks and general economics. The author re-stated some of his ideas on the subject, suggesting, in this case, pipe galleries as a "solution for this anxious municipal problem." The author stated that gas leakage in this country is 10 to 30% of the total gas output, and that besides being ever ready to cause disastrous explosions and fires, and besides so contaminating the air of dwellings as to undermine health, it is causing rapid and complete destruction of asphalt pavements. Still further, as municipal officials know too well, excavations to get at leaky mains is working ruin to all classes of pavements.

Quite a number and variety of other papers were presented, including discussions of municipal administration in Germany, the fire department of Baltimore and city playgrounds.

STATISTICS OF RAILWAYS IN THE UNITED STATES FOR THE YEAR ENDING JUNE 30, 1901.

The operations of railways in the United States for the year ending June 30, 1901, are summarized in a preliminary statement recently issued by the statistician of the Interstate Commerce Commission. We abstract the following information of interest from this statement:

MILEAGE.—On June 30, 1901, the total single-track railway mileage in the United States was 197,237 miles, this mileage having increased during the year 3,891 miles. This increase is greater than that for any other year since 1893, excepting 1900, when it was 4,051 miles. The 16 states and territories for which an increase in mileage in excess of 100 miles is shown are as follows: Alabama, Colorado, Georgia, Illinois, Indiana, Iowa, Louisiana, Minnesota, Mississippi, Pennsylvania, South Carolina, South Dakota, Texas, West Virginia, Indian Territory and Oklahoma. Including tracks of all kinds, the aggregate railway mileage was 265,366.29 miles, which was classified as follows: Single track, 195,570 miles; second track, 12,845 miles; third track, 1,153 miles; fourth track, 876.13 miles, and yard track and sidings, 54,919.86 miles. From these figures it is noted that there was an increase of 6,581.99 miles in the aggregate length of all tracks, of which 2,766.84 miles, or 42.03%, were due to the increase in yard track and sidings. The number of the railway corporations included in the report was 2,057.

EQUIPMENT.—On June 30, 1901, there were 39,584 locomotives in the service of the railways, which was 1,921 more than were in use the preceding year. Of the total number 10,184 are classed as passenger locomotives, 22,839 as freight locomotives, 5,959 as switching locomotives, the remainder, 602, not being classified. The total number of cars of all classes in the service of the railways on the date stated was 1,550,833, there having been an increase of 99,995 in rolling stock of this class. Of the total number of cars, 35,969 are assigned to the passenger service, 1,464,328 to the freight service, and 50,536 to the immediate service of the railways. These figures, however, do not include cars owned by private companies and firms that are used by railways, as no returns for them are made to the commission.

It appears that the railways of the United States used on an average 202 locomotives and 7,926 cars per 1,000 miles of line, that 59,631 passengers were carried and 1,704,005 passenger miles accomplished per passenger locomotive, and that 47,692 tons of freight were carried and 6,439,736 ton miles accomplished per freight locomotive. Embracing in the term "equipment" both locomotives and cars, it is noted that the total equipment of railways at the end of the year was 1,590,417. Of this number 1,164,048 were fitted with train brakes, the increase in this item being 158,319, and 1,549,840 were fitted with automatic couplers, the increase being 145,708. Nearly all locomotives and cars in the passenger service were fitted with train brakes, and of 10,184 locomotives assigned to that service 8,870 were fitted with automatic couplers. Practically all passenger cars were fitted with automatic couplers. Regarding freight equipment, it is observed that nearly all freight locomotives were equipped with train brakes and 89% of them with automatic couplers. Of 1,464,328 cars in the freight service, 1,071,758 were fitted with train brakes and 1,434,075 with automatic couplers.

EMPLOYEES.—The number of persons in the employment of the railways of the United States as reported for June 30, 1901, was 1,071,169, or an average of 548 employees per 100 miles of line. As compared with June 30, 1900, the number of employees increased 53,516, or 19 per 100 miles of line. The classification of these employees shows that 45,292 were enginemen, 47,166 firemen, 32,092 conductors, and 84,493 other trainmen. There were 47,576 switchmen, flagmen, and watchmen. Omitting 3,107 employees not assigned to any of the four general divisions of employment, it appears that the services of 38,816 employees were required for general administration, 343,717 for maintenance of way and structures, 206,418 for maintenance of equipment, and 479,111 for conducting transportation. The amount paid in salaries and wages to employees during the year ending June 30, 1901, it is seen, was $610,713,701, which was $33,448,800 in excess of what was paid during 1900. The compensation of the railway employees for 1901 is equivalent to 59.27% of the operating expenses of the railway companies and 38.44% of their gross earnings.

CAPITALIZATION AND VALUATION.—The amount of railway capital outstanding on June 30, 1901, was $11,688,177,991. This amount, on a mileage basis, represents a capitalization of $61,528 per mile of line. Of the total capital stated, $5,806,597,104 existed in the form of stock, of which $4,475,439,721 was common stock and $1,331,157,383 preferred stock. The amount which existed in the form of funded debt was $5,881,580,887. The amount of capital stock paying no dividends was $2,829,021,925, or 48.73% of the total amount outstanding. Omitting equipment trust obligations, the amount of funded debt which paid no interest was $361,905,203. Of the stock paying dividends 8.82% of the total amount outstanding paid from 1 to 4%, 13.37% paid from 4 to 5%; 10.47% paid from 5 to 6%; 8.71% paid from 6 to 7%, and 6.67% paid from 7 to 8%. The amount of dividends declared during the year was $156,735,784, which is equivalent to a dividend of 5.26% on the amount of stock on which some dividend was declared. The amount of dividends declared in 1900 was $139,597,972.

PUBLIC SERVICE.—The number of passengers carried during the year ending June 30, 1901, as shown by the annual reports of railways, was 607,278,121, showing an increase for the year of 30,412,891. The number or passengers carried one mile—that is, passenger mileage—was 17,353,588,444, there being an increase in this item of 1,314,581,227. There was an increase in the density of passenger traffic, as the number of passengers carried one mile per mile of line in 1901 was 89,721, and in 1900, 83,295. The number of tons of freight carried during the year was 1,089,226,440, a decrease of 12,453,798 being shown. The number of tons of freight carried one mile—that is, ton mileage—was 147,077,136,040. The increase in the number of tons carried one mile was 5,477,978,770. The number of tons carried one mile per mile of line was 700,414. These figures show an increase in the density of freight traffic of 25,048 tons carried one mile per mile of line. The average revenue per passenger per mile for the year ending June 30, 1901, was 2.013 cts. For the preceding year it was 2.003 cts. The revenue per ton of freight per mile was 0.750 ct., while for 1900 it was 0.729 ct. An increase in earnings per train mile appears for both passenger and freight trains. The average cost of running a train one mile also increased. The percentage of operating expenses to earnings was 64.86%.

EARNINGS AND EXPENSES.—For the year ending June 30, 1901, the gross earnings from the operation of the railways in the United States arising from the operation of 195,570.92 miles of line were $1,588,526,037, being $101,481,223 more than for the fiscal year 1900. The operating expenses were $1,030,397,270, having increased in comparison with the year preceding $68,968,759. Gross earnings were in detail as follows: Passenger revenue, $351,356,265—increase, as compared with the preceding year, $27,640,626; mail, $38,453,602—increase, $701,128; express, $31,121,613—increase, $2,705,463; other earnings from passenger service, $8,202,982—increase, $41,960; freight revenue, $1,118,543,014—increase $69,286,691; other earnings from freight service, $4,065,457—increase $719,545; other earnings from operation, including unclassified items, $36,783,104—increase, $385,810. Gross earnings from operation per mile of line were $401 more than for the year ending June 30, 1900, being $8,123.

The operating expenses of the railways already stated were distributed among the four general divisions as follows: Maintenance of way and structures, $231,056,602—increase, $19,836,081; maintenance of equipment, $190,299,500—increase, $9,125,680; conducting transportation, $505,265,789—increase, $36,149,463; general expenses, 566,553—increase, $3,237,788; undistributed, $1[illegible]. The operating expenses amounted to $5,269 per [illegible] line, or $276 more than for the year immediately pre[illegible].

The income from operation, or the net earnings, [illegible] $558,128,767, this item showing an increase as com[illegible] with the previous year of $32,512,463. The average [illegible] of net earnings per mile of line for the year ending [illegible] 30, 1901, was $2,854, and for 1900, $2,729. The amo[illegible] income received from sources other than operation [illegible] $179,746,449. Included in this amount are the f[illegible]ing items: Income from lease of road, $111,637,907; [illegible]dends on stocks owned, $28,822,788; interest on [illegible] owned, $12,055,312, and miscellaneous income, $27,2[illegible]. The total income of the railways, $737,875,215—that [illegible] income from operation, increased by income from [illegible] sources—is the item from which fixed charges and an[illegible]ous items are deducted in order to ascertain the am[illegible] available for dividends. The total deductions of this [illegible]acter amounted to $496,363,898, leaving $241,511,317 as [illegible] net income for the year available for dividends or surp[illegible].

The amount of dividends declared during the year [illegible]cluding $10,752 other payments from net income, [illegible] $156,746,536, leaving as the surplus from the operati[illegible] of the year ending June 30, 1901, $84,764,781. The sur[illegible]plus for the year 1900 was $87,657,933. In the amount stated for deductions from income, $496,363,898, are em[illegible]braced the following items: Salaries and maintenance of organization, $532,290; interest accrued on funded d[illegible], $262,094,838; interest on current liabilities, $5,526,6[illegible]; rents paid for lease of road, $112,644,822; taxes, $50,941,372; permanent improvements charged to income account, $31,939,761; other deductions, $32,081,234.

RAILWAY ACCIDENTS.—The total number of casualties to persons on account of railway accidents, as shown for the year ending June 30, 1901, was 61,794, the number of persons killed having been 8,455 and the number injured 53,339. Of railway employees, 2,675 were killed and 41,142 were injured. These casualties were distributed among three general classes of employees, as follows: Trainmen, 1,537 killed, 16,715 injured; switchmen, flagmen, and watchmen, 175 killed, 1,190 injured; other employees, 963 killed, 23,237 injured. The casualties to employees resulting from coupling and uncoupling cars were employees killed, 198, injured 2,768. The corresponding figures for the year 1900 were killed, 282, injured, 5,229. The casualties connected with coupling and uncoupling cars are assigned as follows: Trainmen killed, 163, injured, 2,377; switchmen, flagmen, and watchmen killed, 25, injured, 284; other employees killed, 10, injured, 107. The casualties due to falling from trains, locomotives, or cars in motion were trainmen killed, 376, injured, 3,147; switchmen, flagmen, and watchmen killed, 26, injured, 222; other employes killed, 61, injured, 452. The casualties due to jumping on or off locomotives or cars in motion were trainmen killed, 65, injured, 1,983; switchmen, flagmen, and watchmen killed, 11, injured, 144; other employees killed, 60, injured, 423. The casualties to the same three classes of employees from collisions and derailments were trainmen killed, 464, injured, 2,508; switchmen, flagmen, and watchmen killed, 11, injured, 81; other employees killed, 60, injured, 566.

The number of passengers killed during the year was 282 and the number injured 4,988. The corresponding figures for the previous year were 249 killed and 4,128 injured. As a result of collisions and derailments 110 passengers were killed and 2,208 injured. The total number of persons other than employees and passengers killed was 5,498; injured, 7,209. These figures include casualties to persons classed as trespassers, of whom 4,601 were killed and 4,858 were injured. The total number of casualties to persons other than employees from being struck by trains, locomotives, or cars were 4,135 killed and 3,995 injured. Casualties of this class occurred as follows: At highway crossings—passengers killed, 3, injured, 11; other persons killed, 828, injured, 1,343; at stations—passengers killed, 21, injured, 344; other persons killed, 378, injured, 553; and at other points along track—passengers killed, 6, injured, 27; other persons killed, 2,899, injured, 1,717. The summaries giving the ratio of casualtiesshow that 1 out of every 400 employees was killed and 1 out of every 26 employees was injured. With reference to trainmen—including in this term enginemen, firemen, conductors, and other trainmen—it is shown that 1 was killed for every 136 employed and 1 was injured for every 13 employed. One passenger was killed for every 2,153,469 carried and 1 injured for every 121,748 carried. Ratios based upon the number of miles traveled, however, show that 61,537,548 passenger miles were accomplished for each passenger killed and 3,479,067 passenger miles accomplished for each passenger injured. The corresponding figures in these latter ratios for the year ending June 30, 1900, were 64,413,684 and 3,885,418 passenger miles for each passenger killed and each passenger injured, respectively.

URALITE: A NEW FIREPROOFING MATERIAL.

Uralite is a new fire-resisting substance now being put upon the market by the British Uralite Co., Ltd., with works at Higham, near Gravesend, England. It is a kind of asbestos mill board

hardened by baking until it has a metallic ring when struck.

The basis of uralite is asbestos, mixed with whiting. The total thickness of a uralite sheet is obtained by building up successive layers, each about 1-50-in. thick, on a special mill board machine, until a standard thickness of 3-32-in. is secured. After the first layer is finished on the collecting roller, a felt roller is brought into contact with the film and moistens it with a mixture of waterglass and sodium bicarbonate in solution; this solution cements the layers together in succession, and the finished sheet is finally cut into pieces about 6 ft. 2 ins. by 3 ft. 1 in. These moist cut sheets are built into a pile separated by a wire mat, or a sheet of iron plate, alternating, until the total height of the pile is about 40 ins. This pile is placed under a hydraulic press, and the pressure is slowly increased until it amounts to 200 lbs. per sq. in. at the end of half an hour; this pressure is maintained for 1½ hours, and the pile is left to harden for 24 hours, after which it is taken to the stoving-room.

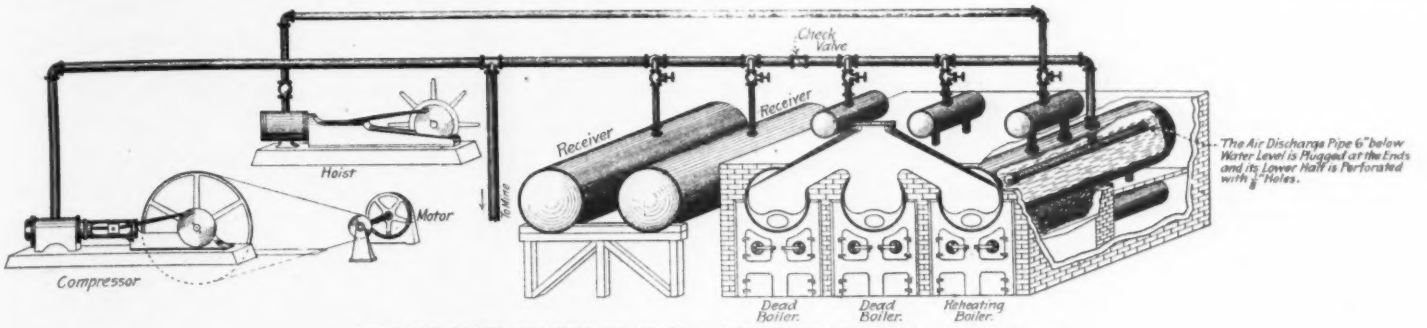
The sheets are now piled, with the edges vertical, on trucks with each sheet kept separate by a skeleton frame of wrought iron ½-in. thick, to permit the escape of moisture. The trucks are run into a stove, 138 ft. long by 5½ ft. wide by 7 ft. high, and the baking is carried on very slowly. To this end there are three series of these stoves, one over the other; they are heated by a flue passing along the bottom of the entire length of the stove. The heat is obtained from a burner at one end of the flue, using producer gas as a fuel. In the upper stove the temperature ranges from 20° C. at one end to 75° C. at the burner end. The trucks enter at the coal end and take 24 hours in passing through this stove; in the middle stove the temperature is 35° to 120° C., and again 24 hours is consumed in passing through; and in the bottom stove, the temperature is 100° to 250° C. and the time of transit 24 hours.

On leaving the last stove the truck load of sheets is wheeled to the chemical house, where it is lowered bodily into an empty tank, and this tank is filled from below with a solution of sodium silicate, in which it remains for 2 hours. It is then removed, allowed to drain for one hour and again passes to the low temperature stove and remains there 36 hours. The sheets are then brought back to the chemical house and dipped in a solution of bicarbonate of soda, and remain in this solution for 24 hours. On removal the sheets are washed for 2 hours, drained for an hour, and then again passed through the series of stoves. The sheets are now pretty hard, but to improve them they are again treated in the silicate and bicarbonate tanks, washed in hot and in cold water, and subjected to a final stoving. In this last operation about 90 sheets are piled up with the gauze and iron plates as before, and to keep them flat each pile is loaded with 5 or 6 cwt. of cast iron. After the final stoving the sheets are immersed in a solution of calcium chloride, and the soda remaining in the sheets is thus completely removed.

The uralite thus prepared can be planed, sawed or cut; it takes glue well; and will not split under nailing. The sheets weigh from 10 to 11 oz. per sq. ft.

Tests of this new material have been made by the British Fire Prevention Committee, and these are reported in "Engineering" of Aug. 15, from which our description of the manufacture has been taken. These tests so thoroughly establish the fire-resisting qualities of uralite that it is now being used by the Liverpool Overhead Railway for covering wooden station platforms. It was tested with four doors of different makes, closing openings in a small building, which was then half-filled with burning timber. One door was wood covered with tinplate; another door had this tin covered with a couple of layers of uralite nailed on; and in another the uralite alone was used to protect the wood. In both the latter cases the doors stood well, letting no flame through in a test lasting 1½ hours, and with a heat of 2,350° Fahr. A wooden deed-box, protected inside and out by sheets of uralite, withstood a similar fire 1½ hours. On opening this box the papers inside were completely free from all signs of charring.

The present works turn out about 5 tons of finished material per day; but this output can be largely increased. They also make a soft uralite, which is a better insulator and is an excellent material for forming steam or water joints. The cost of uralite is not given in "Engineering," but another English journal says it is about equal to the cost of galvanized iron.



ARRANGEMENT OF BOILER PLANT FOR REHEATING COMPRESSED AIR.

REHEATING AIR FOR A COMPRESSED AIR MINE HOIST DRIVEN BY ELECTRIC POWER.*

By C. O. Poole,† M. Am. Inst. Elec. E.

The mine superintendent takes kindly to the electric motor for all purposes except for hoisting, and to my mind his exception is well taken, for until a simple, better and more reliable electrical hoist is developed, I will hesitate to recommend them to a customer. In my opinion, compressed air is going to be universally used for hoisting purposes, where cheap electric power is obtainable and when an air compressor is required for other purposes in the mine. In the ordinary use of a compressor at a mine, it is not used to its rated capacity more than 40% of the time. If, then, receiver capacity be available to store the air at times of light demand upon the compressor by the drills, and thus enable the compressor to be operated at full load all the time, the motor and compressor would be run at their highest efficiency, and sufficient air could be stored to operate the hoist under ordinary conditions, and quite efficiently, too, by reheating the air. It is not generally known that a pound of coal used for reheating air will produce a horse-power hour, while it requires from 4 to 5 lbs. of coal to give the same result with steam; but such is the case if the air be used in an engine fitted for the purpose.

But, for the sake of argument, let us suppose that we use the air without reheating, and assume that air and steam are equal as far as expansive effects are concerned; then, if electric power costs $6.50 per HP. per month, and the compressor has an efficiency of 60%, the cost for air delivered to the engine will be $10.83, and by using a small amount of fuel for reheating, these results can be far exceeded.

At the Lightner Mine, Calaveras county, Cal., electric power has been used exclusively for several years. A 150-HP motor drives a two-stage compressor 13 × 21 × 22-in. stroke, and running at 75 revs. per min. The sawmill, a pump and a blower are also driven by the same motor. The relief pipe from the air receivers is connected to the steam boilers, two of which act as additional receivers, and another one of them being used as a reheater. About one cord of wood is burned per day in reheating. There is operated a 60-stamp mill, which is driven by a 100-HP. induction motor; a 20-HP motor drives the rock crusher, and a 5-HP. motor is used for operating a telpherage system for carrying sulphurets to the chlorination works. All the hoisting is done with compressed air, as is also the lifting of all the water, which is taken from the 600-ft. level. In addition to this work, seven 3¼-in. drills are supplied with air from the same compressor. The total power bill for January, 1902, was $1,457.50, including the cost of the wood used for reheating purposes, which makes the power cost per ton of ore milled to be 21 cts., including all power charges.

The engraving herewith shows the arrangement of compressor and receivers that have given such excellent service at the Lightner Mine. It will be observed that a check valve is placed in the relief pipe, between the mine receivers and the boilers. Any excess of air flows through check valve into the boilers, and the air that is used for hoisting is all taken from the reheating boiler; the air passing into this boiler enters through a perforated pipe, which is submerged about 6 ins. below the surface of the hot water. This arrangement permits all of the air to come in contact with the hot water, and is very rapidly heated. As air is drawn from this boiler by the regular steam pipe, and the pressure is lowered, air from the other boilers and receivers immediately flows in, thus utilizing all of the receiver capacity for the hoist during moments of heavy demand. Between skips, the compressor has time to recharge the receivers.

With an installation of this kind properly proportioned as regards motor, compressor and receiver capacities, to my mind, it leaves little to be desired from the point of economy, convenience and reliability.

At the present time there are several large compressed air plants in course of erection in Amador county, all of which are to be electrically driven, and reheated air is to be used for hoisting.

*Extract from a paper read at the Sixth Annual Convention of the Pacific Coast Electric Transmission Association.

†Manager Standard Electric Co., San Francisco, Cal.

CRENOTHRIX AS A SOURCE OF TROUBLE IN PUBLIC WATER SUPPLIES.

Crenothrix in public water supplies has long been known to give serious trouble through the precipitation of iron. It now appears that the same organism occasionally precipitates aluminum and, rarely, manganese. An interesting study of the subject has just been made available in this country by a reprint from "The Journal of Society of Chemical Industry" for May 31, 1902, of a paper by Mr. Daniel D. Jackson, on "The Precipitation of Iron, Manganese and Aluminum by Bacterial Action."

Crenothrix is found chiefly in ground waters deficient in dissolved oxygen, and at the same time containing the salts which it precipitates. The organism also seems to be favored by "the presence of much organic matter, the absence of light, and the presence of carbonic acid." At Berlin, in 1878, wells sunk near Lake Tegel had to be abandoned on account of iron due to Crenothrix, and at Rotterdam, in 1887, filters treating water from the River Maas had to be abandoned for a like cause. Water from streams largely fed by ground water, and from filters so operated as to give a deficiency of dissolved oxygen, are liable to suffer from Crenothrix, and the dead ends of water mains may become a fruitful place for the growth of the organism.

The general appearance of Crenothrix is described by Mr. Jackson as follows:

> The growth of Crenothrix, wherever it occurs in water, causes a disagreeable turbidity which may be yellowish white, yellow, red, brown, or black. It may be stringy in appearance, but usually occurs in flocculent masses, which in time settle to the bottom of the bottle in which the water may be collected. Under the microscope these masses are shown to consist largely of an organic growth composed of long strings of bacteria, inclosed in a gelatinous sheath in which is imbedded the precipitated metallic hydrate.

The three species of Crenothrix are found in waters high in iron, aluminum or manganese, and it is probable that the aluminum "must be present in the form of sulphate or in combination with carbonic acid and organic matter." Creno-

thrix kühniana precipitates iron, the organism being "red or reddish brown in appearance." Crenothrix ochracea (formerly known as Leptoprix ochracea) precipitates aluminum, the color of the organism being "white to yellowish white," or ochre, "as it nearly always precipitates some iron with the aluminum," Crenothrix manganifera precipitates manganese, and "is dark brown or black in appearance." As yet, it has been found in but two localities, in the Neponset River and in the Newton filter galleries, both in Massachusetts.

Chemical analyses of the material precipitated by these organisms

show that about one-third of the entire dried precipitate consists of the special oxide which the species throws down in the form of hydrate; another third or more consists of organic matter, and is chiefly that which is the living portion of the organism; while the remainder, which may be merely accidental and not a true constituent, is largely silica and aluminum silicate.

The paper closes with the following theoretical and practical conclusions:

THEORETICAL CONCLUSIONS.

(1) Each of the three species seems to use a selective power in precipitating the special oxide ascribed to it, and about one-third of its dry body weight is composed of the oxide selected, whether it be of iron, manganese, or aluminum.

(2) Crenothrix kühniana is very common because iron in quantity is a common constituent of water; Crenothrix ochracea is rather uncommon because aluminum sulphate or aluminum combined with carbonic acid and organic matter is uncommon in water; Crenothrix manganifera is very rare, because manganese seldom occurs in sufficient quantity in water to produce a noticeable growth of the organism.

(3) The growth of all three species is due to the lack of oxygen, with a consequent reducing action in the soil or water. This reducing action may be produced by stagnation in the bottom of ponds or by improper or too rapid filtration in wells or filter galleries, thus causing the solution of iron, manganese, or aluminum from the soil. These, combined with organic matter, seem to furnish the food material for the organisms, whilst the oxides of iron, manganese or aluminum which are precipitated in their gelatinous sheaths are the dross of the operation.

PRACTICAL CONCLUSIONS.

(1) Keep the water of wells and filter-galleries as thoroughly aerated as possible, and blow off the dead ends of pipes frequently when there is danger of the loss of dissolved oxygen. The Crenothrix in the latter case takes its iron from the pipes themselves.

(2) Avoid driving wells through large deposits of peaty matter.

(3) Avoid driving wells or filter-galleries too close to the shores of ponds or streams having large deposits of organic matter on their banks.

(4) Avoid pumping too heavily from any wells or filter-galleries, as the conditions are often thus produced which are favorable to disastrous growths of Crenothrix.

REPORT OF THE BRITISH ADMIRALTY COMMITTEE ON NAVAL BOILERS.

Just two years ago the British Admiralty authorities appointed an expert commission to investigate the working of Belleville water-tube boilers in the British Navy, and report in general as to the relative merits of Scotch boilers and water-tube boilers for naval use, and as to the types of water-tube boilers worthy of trial or adoption.

As many of our readers will remember, the Belleville water-tube boiler—a French invention—has been very extensively introduced in the British Navy during the past half-dozen years, and most of the newest and best vessels are equipped with it. It encountered strong opposition from the first, and later, when experience with the Belleville boiler developed a number of serious defects, the criticisms of the Belleville boiler became so severe that the subject gave rise to heated discussions in Parliament, until finally the appointment of a special commission was determined upon.

We print the report of this Commission below, together with an additional report signed by Mr. John List, of the Commission, the Superintending Engineer of the Castle Line of steamships. It will be seen that the Commission favored the water-tube boiler for naval purposes, but practically condemn the Belleville boiler. Perhaps the most important recommendation of the committee is the equipment of large cruisers and battleships with both cylindrical and water-tube boilers, the former to be used for all ordinary cruising and the latter for use only when the full power of the vessel is required. It is likely that this practice will be generally adopted in future naval construction.

The report follows:

1. The committee desires now to approach their Lordships with a report, intended to be as nearly final as the circumstances of the case will permit, in regard to some of the questions raised in the Letter of Reference, dated Sept. 6, 1900, and their Lordships' letter of Feb. 28, 1901; although, for reasons which are afterwards stated, they are not in a position to "authoritatively recommend a standard boiler for the use of H. M. Navy," as requested in the letter of Feb. 28, 1901.

WORK DONE BY THE COMMITTEE.

2. The work done by the committee has been as follows: The investigation of the behavior of water-tube boilers in British and foreign navies and in mercantile vessels, by visiting many ships in these services, and by obtaining evidence from Admiralty and dockyard officers; from a representative of the Board of Trade; from superintending engineers who have had experience with the design and up-keep of such boilers; from makers of these boilers and from officers entrusted with the care of them.

The supervision of trials in H. M. ships "Europa," "Diadem," and "Minerva," the Cunard steamship "Saxonia," H. M. ships "Hyacinth," "Sheldrake," "Espiegle," "Fantôme," and "Seagull."

The consideration of a large number of different types of water-tube boilers; and in cases where water-tube boilers of types intended for use on shipboard have been under steam on shore, inspections of them have been made, and their behavior enquired into.

The examination of the engine-room registers of 15 of His Majesty's ships fitted with Belleville boilers and 11 fitted with cylindrical boilers, for the period Jan. 1, 1901, to Sept. 30, 1901, in order to ascertain the relative economy and efficiency of these boilers on active service.

They have arranged for the reboilering and the necessary machinery alterations of the "Medea" and the "Medusa," for the purpose of obtaining experience with two types of boilers, the Yarrow large-tube and the Dürr, which had not been previously fitted in H. M. Navy.

Further, such questions as have been put to them by their Lordships from time to time have been answered.

3. The records of their inspections of the evidence, and of the results of the trials, together with the deductions from them, have been forwarded for their Lordships' information in the following documents:

The Interim Report, forwarded Feb. 19, 1901.

The Minutes of the Evidence given before the committee, together with the Appendix thereto, forwarded April 26, 1901.

The report on the trials of "Hyacinth," "Minerva," and "Saxonia," together with the summary of conclusions, forwarded Nov. 27, 1901.

The Progress Report for the year 1901, forwarded Dec. 31,1901.

The report on the relative economy and efficiency of Belleville and cylindrical boilers in commissioned ships, forwarded April 29, 1902.

INVESTIGATION OF THE BELLEVILLE BOILER.

4. It was desired that the committee should investigate and report as set forth in paragraph 3 of the Letter of Reference. In section (a) of that paragraph, the committee were requested to "ascertain practically and experimentally the relative advantages and disadvantages of the Belleville boiler for naval purposes, as compared with the cylindrical." In order to comply with this request, the committee have examined the boilers of many of His Majesty's ships, inspected many boiler tubes removed from ships at the home dockyards, received evidence from engineer officers and considered the defect lists received from ships. An exhaustive series of trials between the "Hyacinth" with Belleville boilers, and the "Minerva" with cylindrical boilers, and a full-power trial under service conditions, and of 24 hours' duration, in H. M. S. "Diadem," have been carried out under their direction.

5. Experience thus obtained has confirmed the committee in the opinions expressed in their interim report, viz.: "That the advantages of water-tube boilers for naval purposes are so great, chiefly from a military point of view, that, providing a satisfactory type of water-tube boiler be adopted, it would be more suitable for use in H. M. Navy than the cylindrical type of boiler;" further, that the "Belleville boiler has no such advantages over other types of water-tube boilers as to lead them to recommend it as the best type to be adopted in H. M. Navy."

6. Since forwarding that report the committee have continued their investigations with regard to the Belleville type of boiler, among others, and they have seen no reason to alter what they then said concerning it. They have also carefully considered the remarks made by Messrs. Delaunay-Belleville & Co. upon the interim report and upon the report on the trials of the "Hyacinth," "Minerva," and "Saxonia," but they found nothing in them which alters, in the least, their opinion upon the subject. In these remarks the bursting of a tube in one of the "Hyacinth's" boilers, a serious accident, in the committee's opinion, due to defective circulation, is only mentioned as an occurrence of no importance. The committee fully recognize that the Belleville boiler, when new and in good condition, is a good steam generator, but its rapid loss of efficiency in ordinary work in commissioned ships, the serious character of the defects which have been developed in it and the great care required in its manipulation render it, in the opinion of the committee, undesirable to fit any more of this type in H. M. Navy.

7. Since the reports on the visits of the committee to Paris and Marseilles the use of lime and zinc has checked the rapid deterioration of the boiler tubes experienced in the earlier vessels fitted with Belleville boilers. The committee regret to find, on the other hand, that serious defects in the boiler casings have made their appearance in several cases, and have rendered the vessels in which they have occurred, unserviceable for long periods.

DEFECTS OF BELLEVILLE BOILERS.

8. The disadvantages of the Belleville boiler, as compared with the cylindrical boiler, are as follows:

(a) The circulation of water is defective and uncertain, and the water gages do not indicate the amount of water in the boiler. These causes have led to serious accidents.

(b) An automatic feeding apparatus of a delicate and complicated kind is necessary, in order to make the safe working of the boiler possible.

(c) A great excess of pressure over that in the boiler is required in the feed pipes and pumps.

(d) A considerable excess of boiler pressure over the working pressure at the engines is necessary.

(e) The quantity of water varies at different rates of combustion, although the same level may be shown in the water gages.

(f) Separators with automatic blow-out valves on the main steam pipes are required in order to provide for water thrown out of the boilers when the rate of combustion or the speed of the engines is suddenly increased.

(g) A constant and excessive loss of feed water.

(h) The upper generator tubes are liable to fail by burning or corrosion, and, in economizer boilers, the economizer tubes are still more liable to fail from the same cause. The trouble from this cause has diminished recently, but the liability of these parts to corrosion still exists, and must be regarded as a serious disadvantage.

(i) The up-keep of Belleville boilers has proved to be exceedingly costly, whereas that of cylindrical boilers is trifling, and this disproportion is likely to increase materially with the age of the boilers. On account of the necessity for more repairs, ships with Belleville boilers will be laid up more frequently and for much longer periods than similar ships with cylindrical boilers.

(k) The additional evaporating plant required with Belleville boilers, and their greater coal consumption on ordinary service as compared with cylindrical boilers, has hitherto nullified, to a great extent, the saving of weight effected by their adoption, and in considering the radius of action of ships fitted with them no real advantage has been gained by their use. The committee cannot say, however, whether this may not apply to other types of water-tube boilers. This can only be determined by extended experience.

9. As compared with the cylindrical boiler, a satisfactory water-tube boiler should possess the following advantages:

(a) Less delay in steam raising.

(b) Less liability to damage if the boiler be struck by a projectile.

(c) Greater ease of repair and renewal of parts.

(d) Less weight for the power generated, considering the weight of the boiler installation only.

(e) Ability to carry a higher steam pressure.

(f) Greater fire-grate area for the same floor area, with consequent less forcing for full power.

To a considerable extent these advantages are possessed by the Belleville boiler, but the committee consider that they are more than counterbalanced by the disadvantages enumerated in paragraph 8.

10. From the report on the trials of the "Hyacinth" and "Minerva," it will be seen that during the Channel trials, the Belleville boilers of the former were more efficient, as regards evaporation, than the cylindrical boilers of the latter as originally fitted; but that, after retarders were fitted in the boiler tubes of the "Minerva," the efficiencies were nearly equal. The long runs to Gibraltar and back showed that in several respects, notably in smallness of feed water and in economy of coal consumption, as well as in the immunity from accident during ordinary working, the cylindrical boilers were considerably superior to the Belleville.

11. In reference to the first part of Section (b) of paragraph 3, of the Letter of Reference, the committee are asked "to investigate the causes of the defects which have occurred in these [Belleville] boilers,and in the machinery of ships fitted with them, and to report how far they are preventable either by modifications of details or by difference of treatment, and how far they are inherent in the system." In reference to this matter, the committee have visited many of H. M. ships fitted with Belleville boilers, including the "Powerful," "Ariadne," "Europa," "Hermes," "Furious," "Arrogant," "Niobe," "Diadem," "Hyacinth," "Vestal" and "Good Hope," and have seen the lists of defects reported from the Channel Squadron, Mediterranean Fleet, and the China Station. From the knowledge thus obtained, the committee are of opinion that, as stated in the interim report, "to obtain satisfactory results in working the boilers in face of the disadvantages named . . . more than ordinary experience and skill are required on the part of the working staff."

12. The principal defects which have arisen in the ordinary working of Belleville boilers on board H. M. ships are:

(a) Corrosive decay of the baffles in the steam collectors, and of generator and economizer tubes. This has been caused by the intermittent character of the circulation of the water in the boiler, by which surfaces exposed to heat are alternately wetted and dried, and by the presence of

air in the feed water, which experience has shown to be particularly injurious to feed-water heaters placed in the uptakes of marine boilers; also, until recently, for want of the proper preservative treatment. The rate of decay has now been reduced by the use of lime and zinc, but great care has to be taken in order to prevent choking of the water-gage connections, in consequence of this necessary free use of lime. Belleville boilers, having undrowned generator tubes and a very large amount of feed-water heater surface in the uptakes, are more liable to injury by corrosion than any of the four types of water-tube boilers which are named by the committee as suitable for trial.

(b) The rapid wear of the working parts of the automatic feed apparatus and of the non-return valves in the down-take pipes.

(c) The burning and warping of the uptakes, boiler casings and boiler supports, with consequent falling off in efficiency owing to the leakage of air into the uptakes. Serious injury to the boilers has, in some instances, resulted, from this cause.

The burning of boiler casings and supports can be reduced to a minimum by special design and to some extent by skillful stoking of the fires, but it is probable that this will be a more or less serious working defect in this and other types of marine water-tube boilers.

(d) The melting of fusible plugs, owing to the defective and uncertain character of the circulation of the water. This defect has been a very general source of trouble, but, as these plugs are necessary for the safe working of the boilers, their melting in particular elements cannot be avoided when the rate of combustion under them is varied to any considerable extent.

(e) The deposit in the tubes about the water line, especially in the wing elements. This occurs when the feed water is not pure and a sufficiently active circulation is not being maintained. This serious defect has been the cause of tubes failing in several instances.

(f) Leaky nipple joints. These have given great trouble.

(g) The decay and fracture of the pipes connecting the float chambers and the water-gage fittings to the elements. This has been mainly due to the use of unsuitable material.

(h) The excessive expenditure of coal and of fresh water for boiler-feed make-up, as compared with similar vessels fitted with cylindrical boilers. The expenditure of coal in ships fitted with Belleville boilers has been very high, both for auxiliary purposes in harbor and for propelling purposes. The loss of water has, up to the present, been an unsatisfactory feature in the working of Belleville boilers, notwithstanding all the care which has been taken to guard against it.

Of the above defects, a, b, d and e are inherent in the Belleville system. With reference to h, it is considered that the loss of water is also inherent in the system.

PROPOSED IMPROVEMENTS IN PROPELLING AND AUXILIARY MACHINERY.

13. With reference to the latter part of section (b), paragraph 3, the Letter of Reference, where the committee are requested "to report generally on the suitability of the propelling and auxiliary machinery fitted in recent war vessels, and offer any suggestions for improvement, the effect as regards weight and space of any alterations proposed being also stated," the committee consider that the propelling and auxiliary machinery as fitted in recent war vessels are generally suitable, and the suggestions they desire to make on this matter are set forth in the following paragraphs:

(a) LENGTH OF STROKE AND NUMBER OF REVOLUTIONS.—They consider it desirable, where practicable, to increase the length of stroke, and reduce the number of revolutions per minute, as compared with the recent practice in H. M. service. This was referred to in Sec. 11 of the "Summary and Conclusions drawn from the report on the trials carried out in the "Hyacinth" and "Minerva," where the committee called attention to the advantages of the longer stroke and of reducing the number of revolutions.

(b) CONDENSERS.—Where two main condensers are fitted to each set of main engines the committee consider that auxiliary condensers need not be fitted, if the auxiliary engines are arranged to exhaust into either part of the main condensers.

(c) JACKETS.—With the piston speeds now adopted jacketing is regarded as of doubtful advantage, even at comparatively low powers. It is considered that all jacket steam and drain connections on the high-pressure and intermediate-pressure cylinders may be omitted without loss of economy. They should be retained on the low-pressure cylinders, but only in the machinery of second-class cruisers and larger vessels.

(d) AIR PUMPS.—It is recommended that independent steam driven air pumps should be adopted where practicable, for the following reasons:

(1) The main engines would be relieved of reciprocating parts, which require much attention when running at high speed; there is also a risk of excessive loads coming on the pumps, due to irregularity in the supply of water in consequence of the rolling and pitching of the ship.

(2) The work can, at all powers, be adjusted to the air leakage with resulting economy.

(3) The vacuum can be maintained and the condensers kept thoroughly drained while the main engines are not at work, thus making it more easy to handle the engines.

(4) Hotwell pumps may be abolished.

(5) With slow-running pumps the water can be delivered into the hotwell tanks more free from air than in the case of pumps driven off the main engines.

(6) Auxiliary air pumps may be dispensed with.

In cruiser engines of 22,000 I. HP., if the auxiliary condensers with their air and circulating pumps, and also the hotwell pumps, are omitted, a saving in weight of 10 tons would probably be effected.

(e) ARRANGEMENT OF FEED PUMPS.—The main feed pumps should be placed in the forward parts of the engine rooms, and their speed should be regulated by float-control tanks. Pressure gages should be fitted on the feed-discharge pipes in each firing space. The auxiliary feed pumps should be arranged in the stokeholds as at present.

(f) STEAM PIPES.—The use of lap-welded wrought iron in preference to steel for steam pipes of internal diameters above 4 ins. has advantage. Iron pipes are cheaper, more easily obtainable, as reliable and less affected by corrosion than steel pipes, and, in the larger sizes a riveted covering strip over the weld is not required. In the arrangement of steam pipes large bends should be fitted where practicable, in order to take up the expansion of the pipes, and packed expansion joints should only be used where bends cannot be arranged for.

(g) ARRANGEMENT OF MAIN AND AUXILIARY MACHINERY IN ENGINE ROOMS.—In the later cruisers which have been seen by the committee, the machinery space is so restricted that the necessary examinations and adjustment of the working parts can only be carried out with difficulty. Where this condition exists, parts which are difficult of access cannot be examined as frequently as is desirable, and the machinery may not therefore always be maintained in a thoroughly efficient condition. As this inaccessibility of parts would be a matter of serious moment under the stress of actual war service, it is recommended that, in future designs, more engine-room space per horse-power should be provided than at present. In cases where this cannot be done, it is considered that provision should be made outside the main engine rooms for a portion of the auxiliary machinery.

(h) DIRECTION OF ROTATION OF PROPELLERS.—The committee have had under consideration the relative efficiency of outward and inward turning screw propellers. The available information on this subject is very limited, but the results of some experiments, which have been placed before them, indicate that the balance of advantage is with outward-turning screws. It is considered that this important subject should be investigated by careful experiments with H. M. ships.

OTHER WATER-TUBE MARINE BOILERS.

14. In Sec. (c) of paragraph 3 of the Letter of Reference the committee are requested "to report on the advantages and disadvantages of Niclausse and Babcock & Wilcox boilers compared with Belleville, as far as the means at the disposal of the committee permit; and also to report whether any other description of boiler has sufficient advantages over the Belleville, or the other two types mentioned above, as a boiler for large cruisers and battleships, to make it advisable to fit it in any of H. M. ships for trial." The committee, in their interim report, mentioned four different types of large straight-tube boilers, viz.: (a) Babcock & Wilcox; (b) Niclausse; (c) Dürr; (d) Yarrow large tube; which they thought sufficiently promising for use in H. M. Navy, and they are still of this opinion.

15. These types have few of the disadvantages of the Belleville type, with most of its advantages. They all have "drowned" tubes, and the water level as shown by the gages is practically the level of the water in the boiler; they do not require a much higher pressure to be maintained in the feed pumps than in the boilers, nor in the boilers than at the engines; the use of automatic feed regulators of an extremely delicate type is not necessary; the circulation is fairly well defined, and is much freer than in the Belleville; from such experience and evidence as the committee have had before them, the loss of water will be much less than with the Belleville; and, finally, they appear to be much more likely than the Belleville to be free from accident under ordinary conditions of service.

16. In the course of their investigations, the committee have watched the Babcock & Wilcox boilers fitted in the S. S. "Martello," of the Wilson Line, employed in the Atlantic trade between Hull, Boston and New York, and copies of the reports of their inspections have from time to time been forwarded to their Lordships. These inspections have taken place at the end of every round voyage for 14 months, and the committee's opinion is that these boilers have stood the test of usage in the mercantile marine extremely well. The vessel has run about 91,000 miles since the boilers were put in, and has usually been less than a week in port at either end; the only repairs required have been those of the ordinary up-keep of any boiler, such as fire bars, brickwork, etc., and only six tubes have required renewal. This opinion is strengthened by the inspections of boilers of the same type fitted in the "Numidian," the "Buenos Ayrean," and the "Turret Cape." In the case of the last-named vessel, the boilers have been in use seven years, and cannot have been as well looked after as they would have been in the navy, and their condition when examined recently was satisfactory. The committee have also examined and tested boilers of the same type in H. M. S. "Sheldrake," and find that, although they have been in use for four years, their condition is good and they have given little trouble.

17. The Niclausse boilers were seen at Cherbourg in the "Variag," a first-class cruiser of the Russian Navy, recently built by the Cramp firm at Philadelphia, which had steamed across the Atlantic only; also in the French pilot-school vessel "Elan." Boilers of the same type in H. M. ships "Seagull" and "Fantôme," have been inspected; those in the "Seagull" are several years old, and have proved generally satisfactory.

18. The Dürr boilers were seen under construction at Düsseldorf, while being fitted in place in H. I. M. S. "Prinz Heinrich" at Kiel; and in H. I. M. S. "Sachsen" at Kiel, after two years' work. Boilers of this type are being fitted in the "Medusa."

19. Yarrow boilers of the small-tube type have been seen in the new ship "Königin Regenters," of the Dutch Navy, and in the "Zenta," an Austrian cruiser, which had recently returned from three years' service in Chinese waters. The committee understand that the Yarrow boiler is being installed in the Dutch and Austrian navies, with forced draft on both the closed stokehold system and the closed ashpit system with heated air supply. Two methods of heating the air supply are being fitted, one by means of tubes in the up-takes, and the other by fitting an outer case completely over the boiler and the uptakes, and passing the air supply through the space so formed.

20. Yarrow boilers are being fitted in the "Medea," and were recommended by the committee for use in combination with cylindrical boilers in some of the first-class cruisers of the "Devonshire" class. These boilers are of the large-tube type, with tubes 1¾ ins. diameter, and the committee anticipate they will be more efficient and give better results in service than the small-tube type. The latest Yarrow boilers for the Austrian and Swedish navies are having tubes of 1¾ ins. diameter fitted.

21. The committee have carried out a series of trials with the "Seagull" and "Sheldrake" and the "Espiégle" and "Fantôme." The report on these trials is well advanced, and will be forwarded to their Lordships as soon as ready. The committee would, however, point out that the trials with such small installations cannot be regarded as giving a true indication of what the same types of boilers would do in larger installations. As no large vessels in our navy are, however, yet fitted with boilers of these types, the committee thought it desirable to carry out trials in the vessels available. The results of these trials are satisfactory, and have confirmed the committee in their opinion that Babcock & Wilcox and Niclausse boilers are suitable for trial on a larger scale in H. M. service.

22. The committee were led to propose to their Lordships that Yarrow large-tube and Dürr boilers should be tried in the "Medea" and "Medusa," respectively, as they understood that no ship in H. M. service was about to be fitted with these boilers, while several were with Babcock & Wilcox and Niclausse boilers, and it was thought desirable that trials of each of these four types should take place as soon as possible.

23. The work of fitting the new boilers in the "Medea" and "Medusa" is now well advanced, and the committee hope that their trials will be begun shortly. A report on the results obtained will be forwarded to their Lordships as soon as possible.

24. While they will indicate whether Yarrow large-tube and Dürr boilers are safe and efficient steam generators, the committee do not anticipate that the results of these trials, when taken together with the trials of the Babcock & Wilcox and the Niclausse boilers mentioned in paragraph 21, will enable them to say whether either of these boilers can be "authoritatively recommended as a standard boiler for the use of H. M. Navy;" as the endurance of the boilers, the nature and extent of the defects which will be developed on actual service, the loss of efficiency after prolonged use, and the cost of up-keep can only be determined by lengthened experience.

25. In the ships of the "Monmouth" and "Devonshire" classes opportunity will be afforded for a very important comparison between ships of practically the same displacement and power, fitted with the same type of machinery, but only differing in the types of boilers fitted. The results obtained by these ships on trials and on actual service should contribute to a large extent towards solving the problem as to the best type of boiler for H. M. service.

26. During the course of their investigations the committee have had the following types of water-tube boilers under consideration:

Belleville,	Thornycroft (small-tube),
Niclausse,	Thornycroft-Marshall,
Babcock & Wilcox,	Yarrow (small-tube),
Stirling,	Yarrow (1¾-in. tubes),
Dürr,	Blechynden,
Parker,	Normand,
Braby's Generator,	Lagrafel-D'Allest,
Weir,	Guilleaume
Accessible,	Merryweather,
Myabara,	Montupet,
Vickers & Adamson,	Allan,
Lyall,	Du Temple,
Noble & Irving,	Schichau,
Bannister,	Schulz,
Hohenstein,	Okes-Serve,
Janson (American),	Dixon & Scott,
White-Foster,	Reed,
Thornycroft-Schulz,	Schutte.

27. Several of the above are small-tube boilers which are in use in small vessels of H. M. Navy, but, in the opin-

ion of the committee, they are unsuitable for vessels above the size of third-class cruisers. The following are, as already stated, those considered to be the most worthy of attention as regards suitability for use in large vessels:

Niclausse	Dürr,
Babcock & Wilcox,	Yarrow large-tube.

In addition to these four types, the committee have had the following four under special consideration as being possibly suitable for large vessels:

Weir,	Thornycroft-Marshall,
Stirling,	Thornycroft-Schulz.

It is not recommended that a trial of either of these should be carried out at present, but the committee suggest that their development for marine purposes should be carefully watched.

28. The trials mentioned in paragraph 4 of the Letter of Reference, between the "Hyacinth" and a cruiser with cylindrical boilers, the "Minerva," have been completed, and the full report on these was forwarded to their Lordships on Nov. 27, 1901.

RETARDERS FOR CYLINDRICAL BOILERS.

29. During the trials of the "Minerva," the committee recommended that retarders should be fitted in the boiler tubes, and it was found by trial that the efficiency of the boilers was considerably increased by their use. The committee understand that the boilers of other ships in His Majesty's Navy have been fitted with similar retarders, and they think it right to state that retarders will be found in many cases to render existing cylindrical boilers more efficient and economical than they are at present.

A COMBINATION BOILER EQUIPMENT FOR LARGE VESSELS.

30. From the evidence before the committee, it appears that no type of water-tube boiler at present in use is, on general service, as economical as the cylindrical boiler; also, that a large percentage of the coal used is expended for auxiliary purposes in harbor. Until a thoroughly satisfactory type of water-tube boiler is obtained, the committee therefore recommend that in large cruisers and battleships cylindrical boilers of sufficient power to work the auxiliary machinery, and to drive the ship at her ordinary cruising speed, should be fitted; the steam pressure should be the same for the water-tube and cylindrical boilers, and may conveniently be 210 lbs. per sq. in., so as to give 200 lbs. at the engines. By this means considerable saving in coal will be effected, with a corresponding increase in the radius of action and general usefulness of the vessel. The water-tube boilers could be kept clean and perfectly efficient, as they need only be used for driving the ship at high speeds, when economy of coal relatively is not so important. The cylindrical boilers should be fitted with retarders in the tubes, and with special means for circulating the water while raising steam.

USE OF WATER-TUBE BOILERS IN OTHER COUNTRIES.

32. From the information which has been brought to the notice of the committee, it appears that water-tube boilers are being very little used in large ships belonging to the mercantile marine, and that their use in such ships is increasing very slowly. In the British mercantile marine the only type of water-tube boiler installed in ocean-going vessels is the Babcock & Wilcox, in some ships of the Wilson and the Petersen-Tate lines, and in three ships of the Allan Line: in these last, however, only one water-tube boiler is fitted in each vessel, to assist the original cylindrical boilers. In the United States mercantile marine Babcock & Wilcox boilers are used to a small extent, principally in the ships plying on the Great Lakes; Niclausse boilers are being installed in two very large ships of 15,000 HP. In France, Belleville boilers have been working in vessels of the Messageries Maritimes Cie. for many years. The Compagnie Générale Transatlantique have fitted two small vessels, one with Belleville and one with Niclausse boilers, in order to obtain comparative trials.

33. In the German Navy the Dürr boiler has been adopted for all large cruisers, while a combination of cylindrical and small-tube types is retained for battleships, and small-tube boilers only are fitted in the smaller cruisers. In the Dutch, Austrian, and Swedish navies the Yarrow boiler is very largely in use. In the French Navy the authorities seem to be undecided at present as to what boiler to adopt: it is understood that they have recently ordered two battleships, but have not decided on the boiler to be fitted. In the recent large cruisers ordered, the French seem to have chosen a different type of boiler for each ship, probably to obtain a trial of each kind. The Italian Navy have ordered a Niclausse installation for one of their new ships. In the American Navy, many Babcock & Wilcox boilers are in use, although recently Niclausse boilers have been ordered for four of the largest ships.

SUPPLEMENTARY REPORT SUBMITTED BY JOHN LIST.

I agree with the foregoing report, except where modified by the following opinions:

PAR. 6.—BURST TUBE IN "HYACINTH."—This was certainly due to defective circulation, but the defect involves so seriously the question of safety with this type of boiler that it appears desirable to supplement the explanation given.

The appearance of the defective generator element when cut up longitudinally did not indicate that it had been short of water, either when the burst occurred or at any previous time, but did indicate that the tubes below the normal water level had not been overheated to an extent which left any appearance of it. The slight lime wash on those tubes were intact, and they were free from any trace of oxidation. The appearance of the tubes above the normal water level, however, clearly indicated that the circulation of mixed steam and water had been insufficent to prevent them getting red hot.

In my opinion, the explanation of this insufficient circulation is, that the element in question was in the wing, and therefore furthest away from the uptake, with one side of it shielded by the casing, and that the water stood comparatively quiescent at the normal level in that element, while the circulation was probably much more energetic in those nearer the middle of the fire grate.

Similar bursts have occurred in other ships, and are certain to occur more often as the boilers become older, and the tubes above the water level thinner from internal wasting. The "Hyacinth's" boilers had done very little work, and could not in any sense be considered old.

CHOKING OF "MINERVA'S" FERRULES.—Messrs. Delaunay, Belleville & Co., in their communication dated March 9, 1902, say in reference to the endurance trial of "Minerva":

These retarders are probably not unconnected with the choking of the ferrules with which the back ends of the "Minerva's" tubes are fitted.

They also, further on, draw attention to the following paragraph in the committee's report:

The openings in the ferrules were found, on examination at Gibraltar, to be choked up across half or three-quarters of their area by a thick, hard, brown slag, which also coated the surface of the tube plates, and which was not removed until access was gained, after cooling, to the combustion chambers.

They further add:

This circumstance shortened the duration of the trial, although the "Minerva" had 39 tons of coal in her bunkers.

These are points of such importance as affecting the use of cylindrical boilers in H. M.'s Navy that further explanation is desirable.

Having examined one of the back tube plates at Gibraltar before it was cleaned, I am of opinion that the accumulation of slag resulted from the cap parts of the ferrules becoming overheated, and the fine particles of scoria carried by the draft becoming burned onto them, ultimately forming a smooth vitrified coating all over the plate, with small elliptic apertures at each tube end.

This was a serious state of affairs, and it effectually brought the trial to a conclusion. It is, however, entirely at variance with experience in cylindrical boilers of merchant steamers using forced draft.

The "Minerva" had only been under way for about 152 hours, and the average rate of combustion was only 22.36 lbs. per sq. ft. per hour. Many hundreds of steamers are making voyages to all parts of the world with closed ash-pit forced draft, heated air and higher rates of combustion than this. In those ships no ferrules of any kind are fitted, and retarders are invariably used. Coating of the tube plates with slag is unknown, and "bird-nesting," which is quite a different thing, only occurs if the tubes are leaking, from the tube plates being greasy or dirty on the water side—a condition of affairs which is not permitted, because it affects seriously the earning power of the ship. The tubes are 2½ ins. in external diameter, and are in some cases pitched as close as 3⅝-in. centers, both vertically and horizontally. The tube plates are also in very many cases thicker than those in the "Minerva," being for working pressures of 200 lbs. and upwards.

The retarders had, in my opinion, no connection with the choking of the ferrules in the "Minerva," but these caused the formation of the coating of slag referred to.

PARS. 7 AND 12 (c).—Serious defects, not only in the casings, but also in the structural parts of the "Europa's" boilers were apparent on that ship's return from Australia, September, 1900. Admitting the correctness of the statement that the burning of the casings may be reduced to a minimum by skilful stoking, that does not afford much cause for satisfaction, as the minimum appears likely to prove formidable, and as it is improbable that in time of war the stoking will be as good as it is now. Experience of firemen in the merchant service leads me to the conclusion that if men have to be drawn from that source, they will prove much less skilful than trained navy stokers. These considerations point to the desirability of adopting for warships a type of boiler which is not readily damaged by unskilful working.

Damage to the framing of a water-tube boiler may be avoided by arranging it so that even with considerable wear and tear of the brickwork it remains protected. Upkeep on the casings may be reduced by an increase in the weight of brickwork, and non-conducting material, by using thicker plating, and in some cases by leading the air on its way to the ash pits through the space formed between an inner and an outer casing.

PAR. 13 (a).—While agreeing with the desirability of increase of stroke and reduction of revolutions where considerations of weight and space permit, I desire to add that the running on full-power trial of engines designed in accordance with recent Admiralty practice, developing 30,000 I. HP. collective, with a stroke of 4 ft., [illegible] revs. per min., was entirely satisfactory.

PAR. 13 (b).—CONDENSERS.—I agree, but [illegible] to add:

The objections to fitting two main condensers [illegible] each engine room are these:

Increased weight in centrifugal pumps, pipes, [illegible] nections and circulating water carried, due to the [illegible] sity for fitting two main centrifugal pumps (each with [illegible] engine) in each engine room, to ensure equal de[illegible] to both condensers.

Increased weight, due to the large eduction sto[illegible] ves on the low-pressure cylinders with the connecti[illegible] duction pipes.

The risks of mistakes being made, in work[illegible] the valves for the pumps and those between the con[illegible] ers and the engines.

The arguments in favor of the arrangement are:

That if one-half is leaking and the other half ti[illegible] the engines may be worked up to half power while t[illegible] defective condenser is under repair.

That in action, if one-half condenser or its co[illegible] nections is damaged in each engine room, the ship ca[illegible] still steam at half power.

In considering this last argument, the fact that t[illegible] additional connections necessitated by double cond[illegible] ers add to the risk of disablement should be kept in vi[illegible].

In the latest cruisers with inward-turning propellers and the working platforms in the middle line, it is impossible to find space for one large condenser between the engines and the ship's side. When, however, the machinery is arranged for outward turning, with the two L. P. engines together aft, the condenser would, as in former designs, be placed aft also.

As evidence that, apart from arguments based on purely service requirements, very large single condensers give satisfactory results, where the details of construction are in accordance with merchant service practice, mail steamers on the Atlantic may be instanced, of about 35,000 HP. collective, which have only one main condenser in each engine room. It is submitted that the balance of advantage might be found on the side of single condensers, with their simpler connections, and with thicker tubes, tube plates and ferrules, and deeper packing.

Considering that one of the most serious difficulties in connection with condenser leakage is perforation of the tubes, it is submitted that this subject is one upon which the assistance of chemical and metallurgical experts of eminence might with advantage be sought.

PAR. 13 (c).—JACKETS.—I agree, but desire to add:

Separate liners should in all cases be fitted on engines above the size of those in destroyers, even when jacketing is not adopted. The draining of the jackets should be done by a reliable type of trap, and not by hand; also the steam supply to the jackets should be regulated by separate reducing valves of suitable type.

PAR. 13 (d).—PUMPS.—I agree, but have to add that the saving of about 10 tons in weight is upon the following basis: Two single-acting lever air pumps on each set of main engines, 30 ins. in diameter by 13-in. stroke, replaced by a pair of single-acting independent pumps in each engine room, the diameter being 33 ins., the stroke 21 ins., and the speed, at full power, 25 double strokes per minute.

PAR. 13 (e).—ARRANGEMENTS OF FEED PUMPS.—I agree, but have the following additional recommendations to make:

The pumps should be of the vertical direct-acting (not duplex) type, with packed water piston and blow-over steam valve, and the following points of design should have attention:

The pump barrel should be gun metal, with a liner so arranged that a replace one can be readily put in at sea without serious dismantling of connections. These renewable liners should be cast of a special alloy of gun metal which will wear well with the packing of the water piston. That piston should be fitted to the pump rod with a taper and nut below. The pump rod should be hard-rolled bronze, and it should be coupled to a steel steam piston rod. Bronze rods have been found to break in the steam cylinder, at the bottom of the thread of the piston nut, and steel rods have failed in the pump barrel from corrosion.

Where valve levers having sliding surfaces in the cross-head are used the sliding ends should be rectangular and fitted with adjustable gun-metal slips and oil cups; otherwise, with a heavy steam pressure on the slide of the shuttle valve, it has been found that the lever sliding surfaces seize.

Saving of weight over and above that referred to in Par. 13 (d) of report would result from dispensing with the hot-well tanks, feed tanks and grease-filter tanks as at present arranged. The independent air pumps might lift the water direct from the condenser bottom to the upper part of the grease-filter tank, which might, if desired, be built into the ship, and which should have sufficient capacity, independent of the filter proper, to admit of sudden increase of water delivered due to increase of speed of ship. The filtered water would gravitate from the level of the top of the filter proper direct to the float-control tank, which should have the float balanced by a spring or weighted lever, and which should be placed at such a

level that the water will gravitate from it into the suction chests of the feed pumps.

The auxiliary feed pumps should have their steam connections also arranged for working under float control.

PAR. 13 (f).—STEAM PIPES.—I agree, and recommend further that where flanges are not scraped and faced, corrugated-metal jointing washers should be used.

With further reference to the latter part of section b of paragraph 3 of the Letter of Reference, I desire to add the following:

1. STANDARDIZATION.

Submitted that the main and auxiliary machinery, and the connections, in ships of the same class, for which contracts are placed within periods the duration of which may be hereafter determined, should be identical. This would admit of interchange of spare parts, and would render it easier to train the engine room and stokehold complements.

With advance in machinery design, it would be necessary to avoid adhering for too long a period to one standard.

2. TYPE OF PROPELLING MACHINERY.

Submitted, that the four-crank engine with three-stage expansion, as now adopted in the service, is preferable to the three-crank three-stage type, because it not only admits of more perfect balancing, but also keeps down the weight of the low-pressure pistons. It is further submitted that to admit of accurate data being obtained of the steam consumption of four-stage expansion engines at cruising powers, it is desirable to fit a ship with four-crank balanced engines of that type.

3. CYLINDER LINERS, ETC.

Submitted, that whereas in the merchant service with initial pressures up to 215 lbs., and piston speeds of 900 ft. per min., high-pressure cylinder liners of hard, close-grained, cast iron are found quite satisfactory, if a suitable type of cast-iron piston packing be adopted, I consider that steel high-pressure liners, as reverted to in H. M. ships, are open to objection: first, because there are few firms which can produce them sound, the price being therefore high, and there being also delays in delivery; second, because they necessitate the use of bronze packings, which may wear rapidly; and, third, because they introduce some difficulties in construction from the difference in the coefficient of heat expansion between steel and cast iron. It is submitted that the brands, and the definite proportions of those brands, of cast iron to be used for all wearing parts, such as cylinder liners, slide valves, valve faces, etc., exposed to steam should be specified.

4. DESIGN OF CYLINDERS AND STEAM-DISTRIBUTION VALVES.

Submitted, that this, as carried out by first-class makers for H. M. ships, leaves little room for improvement. Piston valves, however, are open to objection for the following reasons:

If fitted with packing rings which are free to expand, the lanterns may become worn for the travel in use at low cruising powers, with the result that when the travel is increased by linking out for full power, the packing rings may catch, involving risk of accident. In mercantile practice this has led to the almost universal abandonment of packings which are free to expand while under steam. The type of ring generally in use can be made larger by putting in slips at the partings, the combination forming a block piston, which is not reasonably steam tight.

The port clearance space with piston valves is excessive, and the amount of wire drawing, due to passing steam through the lantern ports, is considerable.

The cylinders and casings, with double piston valves especially, are complicated, and therefore objectionable from the point of view of obtaining sound castings.

For high-pressure and medium-pressure cylinders, the type of valve which is being fitted to the high-pressure cylinders of the "Medea" and "Medusa" has been found to give excellent results in ships of the Dutch Navy and in merchant steamers. It has the further advantages over a piston valve that the travel for a given opening is less; and that in the event of accumulation of water in the cylinder, the valve and saddle will blow off the face, and go back to place under the action of the saddle springs, thus forming an escape valve of large area.

For low-pressure cylinders, double or treble-ported valves, with relieving rings having efficient packing, and a separate pipe connection to the condenser, are satisfactory. For heavy slide valves of fast-running engines, steam-driven assistant cylinders have proved more efficient than balance cylinders of the usual type.

5. PISTONS AND PACKING RINGS.

Submitted, that cast-steel pistons as in general use in H. M. ships are satisfactory. The following points of design are based on extended experience:

The taper of the piston-rod cone fitting to the piston should not be less than 4 ins. per ft., on the diameter, and the rod should have a collar on it bearing when the cone is thoroughly home. The piston-rod nuts for a mild-steel rod should be forged from selected scrap iron. This practice should be carried out in the case of all large steel bolts, the reason being that there is less risk of the threads biting than if both are of mild steel.

The bearing surface of the cast-iron junk ring on the cylinder wall should be as deep as practicable. This ring should be so designed that with the greater expansion of the steel piston there is no liability to split. The steel flange of the piston should be kept 1-16-in. clear of the cast-iron cylinder wall.

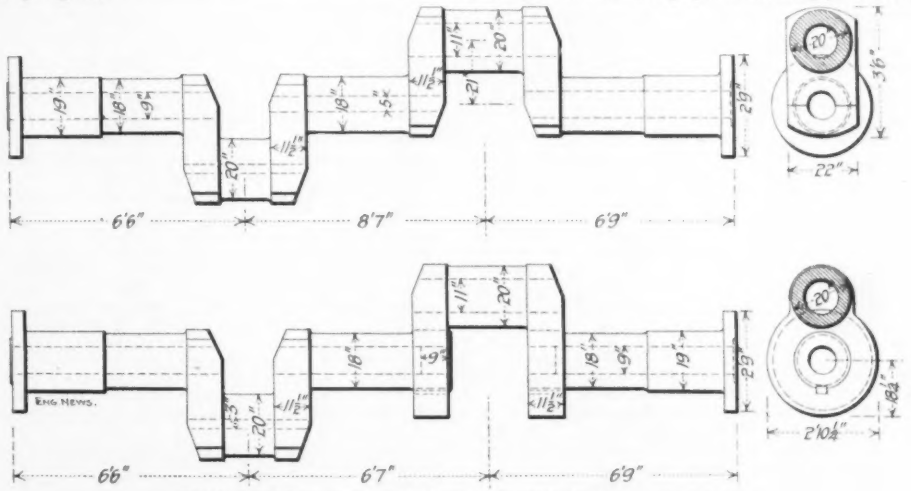
The cast-iron packing rings should be comparatively narrow in bearing surface against the cylinder wall. They should have vertical springs to press them against the piston flange and junk-ring face, and radial springs to set them out. They should also be fitted with strong tie plates which are readily adjustable.

Instead of junk-ring collar studs, with gun-metal nuts and a wrought guard ring, as fitted in the service, the general practice in the mercantile marine is to use turned-steel pins, tapped into gun-metal bushes which are screwed into the cast-steel piston. These pins have square heads bearing on faced soft brass washers; each pin is marked to place, and they are screwed down with a box spanner and a long wrench. This, it is submitted, is a more reliable arrangement than that used in the service. The exact description of cast iron for junk rings and packing rings which will wear well with a given mixture of metal in the cylinder liner, is a point of great importance.

6. PISTON-ROD AND VALVE-SPINDLE PACKINGS.

For piston rods it is submitted that a suitable design of metallic packing should be exclusively adopted, and that for the same diameters of rods and steam pressures the packing and springs for it should in future work, be standardized throughout the service. For valve spindles a standard make of fibrous semi-metallic packing should be adopted.

The objects of such standardization are efficiency and economy, with, at the same time, uniformity in the operations to be carried out by the artificers. The satisfactory performance of these, as regards adjustments of packings, are essential to the successful running at full power of warship engines.



TWO DESIGNS OF CRANK SHAFT FOR NAVAL VESSELS.

7. FITTING OF WHITE-METAL CROSSHEAD-PIN DETAILS.

Submitted, that white metal in all reciprocating parts, such as guide shoes, should be specified to be machined and fitted to place, and not simply cast in; also that all crosshead pins and other bearings upon which the bushes only partially rotate should be specified to have flats machined on the sides to reduce unequal wear.

8. WHITE METAL.

Submitted, that for lining bearings, crank-pin bushes and other parts, exclusive of crosshead bushes, the following alloy has, in hard ocean steaming, been found, after extended experience, to give good results: 12 parts tin, 1 part copper, 1 part antimony, mixed in the following way: six parts tin alloyed with 1 part of antimony, and 6 parts tin with 1 of copper, and the two mixed together.

For lining crosshead brasses the following harder alloy has been found to give good results: 85% tin, 5% copper and 10% antimony.

9. NICKEL-STEEL.

It is submitted that steel of this class offers advantages for forgings of warship engines where lightness is important, but that careful annealing after forging is essential.

10. VALVE GEAR.

Submitted, that adjustable-link motion, with double-plate links, according to the best design in H. M. ships, leaves little room for improvement, but advantage would result in some cases from running the lower halves of the eccentric straps in troughs containing a mixture of oil and fresh water.

It is further submitted that it is desirable to watch developments in connection with a type of modified valve gear (Patent No. 3761 of 1901), which is being introduced into locomotive work, with a view to ascertaining whether the adoption of it in warship machinery offers any advantages.

11. CRANKSHAFTS.

Submitted, that in second-class cruisers, and ships above that power, the design of the crankshaft in two lengths, each length having two cranks almost diametrically opposite, is open to objection from the point of view of the difficulty of obtaining sound forgings. Design "9" (see below) shows the type of shaft referred to as fitted in the cruisers "Kent," "Lancaster" and "Cornwall." In this case the crank throws are so close together fore-and-aft, that the part of the shaft between them cannot be satisfactorily forged, and only a 5-in. hole is bored through that part. Also a very heavy ingot, compared with the finished weight, has to be used for the manufacture of such a shaft, and the risk of defects showing up in the course of manufacture is considerable. If such shafts are forged with the two throws in line, and then twisted through nearly 180°, the result as regards soundness is doubtful. If, however, the shaft is made in accordance with design "C," every part can be more thoroughly forged, and there is the further advantage that the manufacture of the pieces can be proceeded with up to the stage of cutting the key beds and shrinking, before the balancing calculations and diagrams are completed.

The weight of one double-throw piece to design "B" is 10.14 tons, and to design "C," 11.13 tons; difference, .99 of a ton, or 3.96 tons total increase of weight on the crankshafts in the ship. The shafts would be still more reliable if all the cranks were shrunk on, and the extra weight in the ship would be 8.84 tons, compared with design "B." It is submitted that built shafts of this type are preferable to what is specified for the "Devonshire" class, where there is a coupling between each pair of cranks, involving considerable increase in the total length of the machinery.

12. GREASE FILTERS.

If these are arranged as suggested above (paragraph 13e) the amount of surface might, with advantage, be increased 50%, compared with recent Admiralty specifications. For efficiency, the governing condition is as large a surface, and, therefore, as low a speed of flow through the medium as considerations of weight and space permit. Towelling in three strata as used in the service is on the whole satisfactory. From the point of view of keeping down weight of construction, the 30-lb. test pressure which has been specified for grease filters, irrespective of the working pressure to which they can be exposed, is undesirable.

13. CENTRIFUGAL PUMPING ENGINES.

Submitted, that these for main and auxiliary condensers, as fitted in H. M. ships, are satisfactory, where not also used to drive air pumps. The steam cylinders should be of sufficient size to do the maximum work with not more than 120 lbs. initial steam pressure. With single-crank engines the exhaust should be arranged with a separate change valve to the condenser, as, when running at moderate speed, with maximum back pressure on the closed exhaust system, there is risk of stopping on the dead centers. Balanced slide valves are less wasteful of steam than piston valves, and involve less risk of breakdown due to water being thrown into the cylinders from long ranges of pipes by the motion of the ship. A slide valve will blow off the face, whereas a piston valve may lock the water into the cylinder.

14. AUXILIARY STEAM PRESSURE.

Submitted, that the balance of advantage is in favor of a pressure not exceeding 120 lbs.

15. FIRE AND BILGE PUMPS.

Submitted, that, as duplex pumps give a more uniform delivery than double-acting single-barrel pumps, it is desirable to fit them in preference to the latter, where used for fire-extinguishing purposes only. Where, however, the same pump may be used for bilge pumping, fire and sanitary work the balance of the advantage lies with the single-barrel type, provided that it is not of so small a size

that there is trouble from the shuttle valve sticking. The pump barrels in any case should be of gun metal, with easily-renewable gun-metal liners and gun-metal valves. The pump pistons should have ebonite packing rings, where cold, clean, fresh water, or sea water, is to be pumped. For hot or impure water white-metal packings, which can be readily renewed are preferable.

16. CRANK-PIT PUMPS.

Submitted, that it is desirable in large ships to fit a steam pump in each engine room, to be used for this work when the ship is under way, and that it should be of the duplex type, having gun-metal pumps, with the pump pistons, packed with white metal, and with gun-metal valves. Each pump should be steam controlled by a float sunk into a small well in the double bottom, at the lowest part of the crank pit. That the pump may have to be at some distance from the steam-controlled cock is immaterial.

17. CLOSED EXHAUST EVAPORATORS AND DISTILLERS.

Submitted, that the closed exhaust system, and the evaporators and distillers for working in connection with that system, and with live steam, according to the latest service practice, are satisfactory. If auxiliary condensers are not fitted, or are not used when under way, the coil drains would be led to the main condensers.

18. DYNAMO AND FAN ENGINES.

Submitted, that these as fitted are satisfactory, except that the cylinders should be kept of such size that the initial steam pressure does not exceed 120 lbs. Slide valves are preferable to piston valves for the reasons given in clause 13 above.

19. AIR SUPPLY TO FANS.

Submitted, that when permanent cowls are abolished, the question of efficient downcasts to the fans requires consideration, as canvas windsails are not satisfactory. One solution of the question is a rectangular steel trunk having a hinged flat top.

20. AUXILIARY CONDENSERS.

Submitted, that except where double-main condensers are used, these as at present fitted are satisfactory, but that the service system of keeping one in use when the ship is under way, and even throughout long voyages, is uneconomical and unnecessary. In merchant steamers which have in some cases as many auxiliary engines as a first-class cruiser, and which have to stop at calling ports, with the electric-light installation, and many other auxiliaries at work, no difficulty is found in exhausting all these to the main condensers, both when the main engines are running, and when they are stopped, and this holds good even in the case of air pumps driven off the main engines. With independent main air pumps, regulation of the speed of the electric light engines or other auxiliaries on account of the vacuum being broken when the main engines stop is, of course, obviated.

21. STEERING ENGINES.

Submitted, that the service system of exhausting this to the auxiliary condenser is, as pointed out in the preceding paragraph, uneconomical, because it involves running the pumps in connection with that condenser. Considerable steam economy results from the comparatively recent practice of fitting to steering engines a type of supplementary cut-off valve, which is automatically worked by the control gear.

22. EVAPORATOR FEED PUMPS.

Submitted, that double-crank pumps with ordinary slide valves worked by eccentrics are preferable to direct-acting pumps with blow-over steam valves, as that type of valve is apt to stick in the small sizes.

23. ELECTRIC DRIVEN AUXILIARIES.

Submitted, that motors are suitable for driving fans of moderate size, small centrifugal pumps, and in some situations geared crank pumps, but that they are not suitable for use with capstans, hoists, winches, or other appliances essential to the safe handling or fighting of the ship, and in which the load may exceed the power of the motor, as in that case the fuse may be burned out or the armature damaged at a critical time.

PAR. 19.—HEATED AIR SUPPLY TO LARGE TUBE YARROW BOILERS.

Considering that with this type of boiler the course of the gases to the uptakes is very direct, at full power overheating of the upper parts of the casings may prove a source of trouble. For this reason the systems of closed ash-pit forced draft, with air heaters and casings, which are described, may be found advantageous. In cylindrical boilers having air-heating tubes in the uptakes, buckling of the lower tube plates of these sometimes results from "flaming." This causes leakage of the air under pressure into the uptakes, with resulting falling off in the performance of the boilers. That points to the desirability of using with Yarrow boilers either a type of tube air heater in which the tube plates are not exposed to direct impact of the hot gases, or one such as that last referred to in paragraph 19, where possibly the casing plates might buckle to some extent and still keep tight at the landings, if close riveted, with a strand of asbestos between. The arrangement of double casing has the further advantage that it secures cooler stokeholds.

PARAGRAPH 21.

I am of opinion that a type of water-tube boiler which involves in its construction machine work of extreme accuracy, and for which the refinement of gages is necessary, may ultimately prove less suitable for H. M. ships than a type which does not require for its manufacture and up-keep machine tools of a character differing greatly from those generally used in boiler making.

PARAGRAPHS 26 AND 27.

The committee's attention was, by the terms of reference, not specially directed to "Express" boilers, and therefore no such examination has been made into the relative merits of those most in use which warrants any very definite expression of opinion.

THORNYCROFT-SCHULZ BOILER.—In progress report, 1901, at p. 38, reference is made to the boilers of this type which were examined under construction at the Germania Works, Kiel, for a German battleship, to be used in combination with cylindrical boilers.

It appears from evidence put before the committee (pp. 282 to 286, "Minutes") that this type of boiler is in use in the battleships and cruisers of several other foreign powers.

Where the following points of design are carried out, I consider it suitable for use in combination with cylindrical boilers in ships above the size of third-class cruisers in H. M. Navy:

1. The tubes to be of not less than 1¾ ins. in external diameter and not less than No. 8 L. S. W. G. thick.

2. The curvature of the tubes to be such that a flexible cutter can be passed through them for the removal of scale.

3. The arrangement of the tubes to be such that only a small percentage discharge above the water level, and that there are no air locks in them when the boiler is filled right up.

STIRLING BOILER.—This, in its land form, is coming extensively into use. In its marine form it possesses several good features, and has been at work on land and also in a sea-going vessel for some time with success.

WEIR BOILER.—This also has been at work on land for some considerable time with success, and when submitted to a careful examination by the committee was found to be in good condition.

THORNYCROFT-MARSHALL BOILER.—This type, with large single-back header, has also been at work on land for some considerable time with success.

I am of opinion that these three boilers which are all of the large-tube type, and which have passed the experimental stage, are worthy of trial in vessels attached to the dockyards where their performance could be carefully watched, and where trials could be made at sea for extended periods under service conditions.

SCHICHAU BOILER.—This I consider has features of design which warrant that its further development should be closely followed.

PAR. 29. RETARDERS.

I would suggest further that a trial of retarders without ferrules be made in an existing ship having suitable cylindrical boilers, and in which efficient grease filters are fitted.

PAR. 30. COMBINATION INSTALLATIONS.

Where in these a type of water-tube boiler is used which is fairly light, and which admits of considerable forcing, I consider that the balance of advantage is in favor of combining with these about 30% of the full power in cylindrical boilers rather than about 20%. The larger proportion would avoid forcing unduly the cylindrical boilers, and would admit of the water-tube boilers being less often used, which would not only economize coal, but also reduce wear and tear on the firebrick work[illegible] cas-
ings. At the same time it would admit of ea[illegible] out
thoroughly the very careful and systematic cl[illegible] and
overhauling which is essential if boilers of that[illegible] are
to be maintained over extended periods in a re[illegible] con-
dition for full-power steaming.

I consider it undesirable to limit the loaded pr[illegible] e on
such combinations to 210 lbs., as designs which a[illegible] fore
their Lordships show that 220 lbs. is quite prac[illegible]le in
cylindrical boilers for a first-class cruiser.

HOWDEN'S FORCED DRAFT.

Considering the very extensive adoption of thi[illegible] stem
in the mercantile marine, and its proved adva[illegible]s, I
am of opinion that if carried out in accordance w[illegible] cer-
tain designs which are before their Lordships for [illegible]sers
of the "Devonshire" class, it would give better r[illegible]s in
those ships than closed-stokehold forced draft[illegible] the
cylindrical boilers.

I would further suggest that this system should [illegible] ap-
plied, not only in a cruiser, but also in a battlesh[illegible] spe-
cially designed for an installation consisting ent[illegible]y of
modern high-pressure cylindrical boilers. This wo[illegible]d ad-
mit of comparisons being made, not only with [illegible]ular
ships having all water-tube boilers, but also with those
in which different combinations of water-tube and [illegible]y-
drical boilers are fitted.

A NOVEL APPLICATION OF CONVEYING MACHINERY.

The accompanying cut shows a highly ingenious method of loading vessels on a rocky coast. The plant shown is installed near the city of Vivero, on the northwestern coast of Spain, and serves to load into ships the ore from the iron mines of the Vivero Iron Ore Co. The loading plant consists of an inclined conveyor, which draws material from stock bins located upon the hillside, and is so arranged as to discharge into the hold of a vessel lying out in deep water, about 400 ft. off shore. This arrangement is made possible by supporting the conveyor on a cantilever girder or bridge, as is shown in the view. The bridge rests on an abutment built on a small rock in the water some 250 ft. from shore; the inner end is anchored to the rock of the shore, while the outer end projects about 150 ft. beyond the cantilever support. The conveyor is supported on the top of this bridge, and its buckets dump automatically at the outer end into a telescoping chute which leads down to the hatchway of the vessel to be loaded.

The conveyor is entirely automatic, and operates by gravity, the full buckets going down to the outer end of the bridge, discharging there, and returning to the bins. The length of the conveyor is about 700 ft., and its total fall about 70 ft., giving thus an average gradient of 1 in 10, which appears to be sufficient for operating it. The capacity of the conveyor is 275 tons per hour. The telescoping chute arrangement at the outer end permits of loading even in quite rough weather.

A CONVEYOR FOR LOADING IRON ORE INTO SHIPS OFF A ROCKY COAST.

It may be mentioned also that the storage bins from which the conveyor is fed are supplied from the mines by a cable tramway about three miles long. The whole plant was installed by Adolf Bleichert & Co., of Leipzig-Gohlis, Germany.